Compliments of
J M Rusk
Secretary of Agriculture.

REPORT

OF THE

SECRETARY OF AGRICULTURE

1890

WASHINGTON
GOVERNMENT PRINTING OFFICE
1890

[PUBLIC RESOLUTION—No. 49.]

Joint resolution providing for the printing of the Agricultural Report for eighteen hundred and ninety.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That there be printed four hundred thousand copies of the Annual Report of the Secretary of Agriculture for the year eighteen hundred and ninety; seventy-five thousand copies for the use of the members of the Senate; three hundred thousand copies for the use of the members of the House of Representatives, and twenty-five thousand copies for the use of the Department of Agriculture, the illustrations for the same to be executed under the supervision of the Public Printer, in accordance with directions of the Joint Committee on Printing, said illustrations to be subject to the approval of the Secretary of Agriculture.

SEC. 2. That the sum of two hundred thousand dollars, or so much thereof as may be necessary, is hereby appropriated, out of any money in the Treasury not otherwise appropriated, to defray the cost of printing said report.

Approved, September 25, 1890.

TABLE OF CONTENTS.

LIST OF ILLUSTRATIONS.

REPORT

OF THE

SECRETARY OF AGRICULTURE.

DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., October 25, 1890.

To the PRESIDENT:

I have the honor to submit my Second Annual Report as Secretary of Agriculture.

I deem it to be my first duty in making this report to congratulate you and the country at large upon the generally improved outlook in agricultural matters. At no time in the history of this country has there been so much agitation among the farmers as a class as during the period which has elapsed since I had the honor to submit to you my first report. The causes of this widespread agitation have been so varied and so numerous that to attempt to specify them all would be as tedious as it would be unnecessary in a report of this character. I will only refer to such of the most prominent causes as for various reasons seem to require special mention here.

Naturally the first place in this brief enumeration belongs to a depressed condition of agriculture prevailing at the time that you assumed office, the result of a slight but steady diminution of the prices of most of our staple agricultural products, a reduction which had been going on for some years, and which, therefore, has amounted in the aggregate to a considerable percentage of the average crop values. Severely as such a depression must necessarily have been felt by a class who measure even their prosperity by a very moderate standard of profit, it has not been without its good results.

The attention of the country was thoroughly awakened to the farmer's condition, and agricultural matters were very properly made the subject of special consideration by Congress. The subject was discussed in the press, the views of the farmers themselves were made

known, and it is gratifying to be able to point out that to-day the cloud which for some years seemed to rest gloomily upon American agriculture has been lightened, while the wise economic legislation already secured holds out still brighter promise for the future. As an earnest of this statement, I subjoin a brief table, showing prices of some of our staple agricultural products to-day and a year ago.

Prices of leading agricultural products at Chicago, October 16.

Articles.		1889.		1890.	
Corn	per bushel	\$0.30⅞ to	\$0.31	\$0.50 to	\$0.50¼
Wheat	do	.80⅛	.81½	1.00	1.00¾
Oats	do	.18¾	.19¼	.42	.43
Barley	do	.63	——	.78	——
Flaxseed	do	1.27	1.27½	1.45½	1.46
Buckwheat	do	.38	.45	.55	.65
Hogs	per 100 pounds	3.85	4.20	3.85	4.50
Cattle, choice	do	4.00	5.05	4.75	5.30
Sheep, Western	do	3.50	4.20	3.00	4.60

The recent legislation looking to the restoration of the bimetallic standard of our currency, and the consequent enhancement of the value of silver, has unquestionably had much to do with the recent advance in the price of cereals. The same cause has advanced the price of wheat in Russia and India, and in the same degree reduced their power of competition. English gold was formerly exchanged for cheap silver, and wheat purchased with the cheaper metal was sold in Great Britain for gold. Much of this advantage is lost by the appreciation of silver in those countries. It is reasonable, therefore, to expect much higher prices for wheat than have been received in recent years.

In my last report I ventured to appeal most earnestly for a larger measure of tariff protection for the farming industry. "For all such articles as our own soil will produce, the farmer justly asks that protection which will insure to him all the benefits of our home market." Such was the language with which I concluded my appeal on his behalf. I am thankful to say that it has been in a very large measure heeded; and, admitting to the fullest extent the place to which natural causes are entitled in assigning reasons for the higher prices now prevailing for agricultural products, it is impossible not to see the beneficial influence of the tariff protection awarded to the farmer under the present law. A comparison of the duties under the present law on some of the agricultural products heretofore imported in considerable amounts with the rates of duty imposed on them under the old law will illustrate this in a striking manner.

Agricultural imports, fiscal year ending June 30, 1890, *with change in tariff duties.*

	Value.	Old duty.	New duty.
Animals and animal products:			
Cattle	$244,747	20 per cent. ad val.	Over one year, $10. Under one year, $2.
Horses	4,840,485	20 per cent. ad val.	$30, or 30 per cent. if value over $150.
Sheep	1,268,209	20 per cent. ad val.	Over one year, $1.50. Under one year, $0.75.
Cheese	1,295,506	4c. per lb	6c. per lb.
Eggs	2,074,912	Free	5c. per dozen.
Wools	15,264,083		
Class 1 (above and below 30c. per lb.)		10c. and 12c	11 cents.
Class 2 (above and below 30c. per lb.)		10c. and 12c	12 cents.
Class 3 (above and below 12c. per lb.)		2½c. and 5c	At 13c. per lb., 32 p. ct. Over 13c., 50 p. c. ad val.
Flax	2,188,021		
Straw		$5 per ton	$5 per ton.
Not hackled		$20 per ton	1c. per lb.
Dressed line		$40 per ton	3c. per lb.
Tow		$10 per ton	1½c. per lb.
Barley	5,629,849	10c. per bush	30c. per bush.
Hay	1,143,445	$2 per ton	$4 per ton.
Hops	1,053,616	8c. per lb	15c. per lb.
Tobacco	17,605,192		
Unstemmed (leaf)		75c. per lb	$2 per lb.
Stemmed (leaf)		$1 per lb	$2.75 per lb.
All other		35c. per lb	Stemmed, 50c. per lb. Unstemmed, 35c. per lb.
Potatoes	1,365,898	15c. per bush	25c. per bush.
Wines	8,859,956		
Champagne:			
Bottles between pint and quart		$7 per doz	$8 per doz.
Bottles between half pint and pint		$3.50 per doz	$4 per doz.
Bottles less than half pint		$1.75 per doz	$2 per doz.

We have a strong assurance in the recent increase of values of meat products, and the circumstances which now environ production, of continued prosperity of stock raising. New industries now in process of development will increase the ability of consumers to purchase meats; and better protection of wool will open larger domestic markets, as it has already advanced prices. There is an increasing interest in the production of mutton in the central West, and of early lambs in the populous East, indications of progress that promise increase of profit in sheep husbandry. Of chief interest naturally to the stock raisers of this country are the export trade in animals and their products, and the possibilities of still further relieving our home markets of these products by extending our markets abroad.

THE EXPORT TRADE IN ANIMALS AND THEIR PRODUCTS.

Step by step as it were with the vigorous prosecution of the work of exterminating pleuro-pneumonia and controlling Texas fever, and with a more general appreciation of the benefits derived from a judicious exercise of the powers conferred on this Department, we find a gratifying improvement in the export trade in live animals. The total value of animals and fowls exported for the fiscal year ending June 30, 1890, was over $33,000,000, an increase of something over $15,000,000 as compared with the year previous. The increase in the number of cattle was from 205,786 in 1889 to 394,836 in 1890, while

the number of hogs exported increased from 45,128 to 91,148, over 100 per cent. In horses there was a slight reduction of exports, far more than counterbalanced, however, by the large increase in the number of mules exported. In the number of sheep exported there was a decrease.

A very large increase is shown in the export trade in beef and hog products, while in dairy products the export trade in butter was especially gratifying, the figures for 1889 being 15,504,978, and in 1890 29,748,042 pounds. The increase in the value of meat and dairy products exported between 1889 and 1890 was over $32,000,000. At a time when our domestic markets are overcrowded with animals and their products, this increase in the export trade is very encouraging. The prices realized abroad have as a rule been good, and but for the unjust restrictions placed upon both animal and meat products abroad, the increase in the amount exported would have been much greater. Experimental shipments of cattle to Germany and Belgium were made during the year with favorable results, but excessive duties and the quarantine restrictions which were immediately imposed at once destroyed this trade. A careful review of the trade shows how urgent it is that we should secure more favorable regulations in the chief European countries in regard to our exports of animals and animal products. The first step towards the accomplishment of this object was necessarily to secure as far as possible the absolute immunity of our own cattle from disease.

ERADICATION OF PLEURO-PNEUMONIA.

The regulations for the eradication of contagious pleuro-pneumonia have been vigorously enforced during the entire year, and rapid progress has been made. In New York no cases have occurred during the year ending June 30, 1890, except on Long Island. There have been no cases in Maryland since October, 1889. Pennsylvania has remained free from the disease during the entire year. In both Maryland and Pennsylvania constant inspection has been maintained and the complete eradication of the contagion thereby assured. During the two months of May and June, 1890, but 13 affected animals were purchased in the whole infected district as compared with an average of 71½ per month during the preceding ten months. At this writing it would seem that the disease is practically banished from American soil, though the length of time which has elapsed since the last case of the disease was noted by the inspectors has been hardly sufficient to warrant a formal official declaration to this effect.

INSPECTION IN GREAT BRITAIN.

The vigor with which the work of exterminating pleuro-pneumonia was carried on would nevertheless, as far as our export trade was concerned, have been comparatively ineffectual unless simultaneously with its eradication in this country we were able to convince Great

Britain and other European governments of the progress made in ridding the United States of this disease. Early last winter, therefore, I solicited the aid of the State Department in opening negotiations through Minister Lincoln with the British Government, looking to an arrangement which I deemed extremely desirable with a view to putting an end to the frequent allegations that cases of contagious pleuro-pneumonia existed among American cattle shipped to British ports.

The circumstances under which these allegations were made convinced me of the absolute necessity that this Department should be represented at the inspections made of our cattle on landing in Great Britain. Thanks to the cordial co-operation of the State Department and the intelligent activity displayed in the matter by Minister Lincoln, I finally obtained the privilege of appointing veterinary inspectors representing this Department, to be resident in Great Britain, who were to be allowed every facility in participating with the British inspecting officers in the work of inspecting American cattle landed in British ports. As soon as this privilege was secured I appointed three competent officers for this responsible duty and dispatched them to Great Britain in charge of the Chief of the Bureau ot Animal Industry, Dr. Salmon, who remained with them until their duties were clearly defined and the best means decided upon to enable them to carry on their work effectually and in harmony with the British authorities. This transatlantic inspection has been in force for the past two months, and I am happy to be able to state that since it was instituted not a single case has been reported of contagious pleuro-pneumonia among American cattle landed in Great Britain. Indeed, I am now informed that not a single case has been reported by the British authorities themselves since March last.

At the same time that I presented this matter to the attention of the Secretary of State I also placed before him facts bearing upon our meat export trade, showing conclusively the utterly groundless nature of the charges made by other European governments in regard to the unwholesomeness of our meat, but especially of our pork products. I am happy to state that this matter was taken up by the State Department with the same cordiality that characterized its action in regard to our export of live cattle, and that the facts supplied by me to that Department were laid before the foreign governments by our respective ministers so clearly and with such force as will, I am sure, carry considerable weight in the further consideration of this subject by the governments in question.

INSPECTION OF EXPORTED ANIMALS.

The act of August 30, 1890, provides for the inspection of all exported cattle, sheep, and swine. The amount of work required to accomplish this is indicated by the fact that during the year ending

June 30, 1890, the number of these animals exported was as follows: cattle, 394,836 head; hogs, 91,148 head; sheep, 67,521 head. Rules and regulations for this service have been prepared and the inspection is now being made. The necessity of this inspection is shown by the exclusion of American cattle, sheep, and swine from European markets on the plea of the danger that disease will be introduced by them. While this inspection alone might not be accepted as in all cases giving a complete guaranty against the appearance of disease during the voyage, it is an important step in this direction, and will give us the means of knowing officially the condition of the animals as they leave our ports. In connection with the inspection recently established by me at the foreign animal wharves of Great Britain, it will also enable us to trace back animals which may be found affected there, so that the nature of their malady may be determined, and if found contagious the proper measures will be enforced for its eradication.

REGULATIONS REGARDING TEXAS FEVER.

The regulations regarding Texas fever, which went into effect on March 15, though carefully formulated so as to allow the free movement of Southern cattle to market, have been on the whole well observed, and the result has been a marked decrease in the number of cases of Texas fever occurring on farms, in stock yards, or on vessels carrying export cattle. One of the largest buyers and exporters of cattle in the United States reports that, whereas a year ago he dared not buy cattle for feeding or export in the stock yards, but was obliged to go to the farms where he could get evidence that they had not been exposed, this year, on the contrary, he has purchased such animals at the stock yards without fear. Last year his losses from Texas fever, in spite of his precautions in buying, were considerable; the present summer he has not lost one from this cause. He further states that, owing to the immunity from this disease, insurance rates have been reduced from $8 to $3.50 on every $100 worth of cattle, this alone representing a saving of over a million dollars on export cattle. Owing to lack of authority under existing laws, I have, however, been unable in some cases to enforce these regulations, and there is at present no penalty which can be applied in such cases. Owing to such disregard, some cases have occurred of Texas fever imparted to valuable thoroughbred cattle, and these have since died from the effects of the disease.

Proper facilities for separating the two classes of cattle are still lacking at the ports on the Atlantic seaboard, and as a consequence the disease has occasionally appeared among export cattle on their voyage to foreign countries. The influence of this upon the trade is very bad. It is being cited in Great Britain as affording good reason for their continuing the prohibition of the introduction of live cattle

from this country. Ample power to compel immediate remedy of this condition of things is therefore urgently needed. If the regulations of this Department can be properly enforced, the appearance of Texas fever in this country outside of the affected areas will be very rare, and not a single case should occur among cattle after leaving our ports. I have therefore suggested amendments to the act establishing the Bureau of Animal Industry, which are now pending in Congress. If enacted, these will fully provide for the prevention of the spread of this and other communicable diseases of animals from State to State or from the United States to foreign countries. These amendments are essential to rendering the work of this Department effectual. If there is to be control of animal diseases at all, it must be so thorough as to prevent their spread, and thus remove foreign objections to our cattle and meats, give confidence to stock owners and shippers, and secure full protection to farmers.

INSPECTION OF PORK PRODUCTS.

It is with great gratification that I have assumed the duties imposed upon me by the passage of the act of August 30, 1890, in which provision is made for the inspection of salted pork and bacon. The unjust war waged upon our pork products by some of the European governments rendered this provision absolutely necessary as a preliminary step towards any action looking to a removal of the obstacles which now impede our export trade in these products. The absence of inspection on this side provoked an argument on the part of the representatives of foreign governments, to which we were really not prepared to reply. It was that no inspection being held by ourselves, while a rigid inspection was conducted by them of American pork products landed in their countries, they were in a position to know better than we ourselves the actual condition of these products. The present law will enable us to warrant the wholesomeness of our pork products under the seal of official inspection. Having then satisfactorily established the injustice of these foreign discriminations, we shall be in a position to demand their withdrawal, or at least to insist upon a retraction of all charges made on the ground of unwholesomeness or impurity. Armed with a certificate of inspection guarantying wholesomeness on the one hand, and with the retaliatory clause wisely interpolated in this law on the other, we shall, it seems to me, be in a position to provide powerful support to further diplomatic negotiations on behalf of American hog products.

MEAT INSPECTION.

In my report of last year I urged the great desirability of a national inspection of cattle at the time of slaughter, and also an inspection of meats, which would enable this Department to guaranty

that the animal products exported from this country were untainted by disease, and which would reveal at once the presence of any diseases affecting our meat-producing animals. The call for such inspection was not because of any unusual prevalence of disease, since the animals of the United States are probably at present more exempt from such influences than those of any other nation, but because of the unfounded statements of disease which have been made the pretense for the restrictions and prohibitions which the governments of other countries have enforced against our animals and their products. None of these restrictions upon the sale of our meats have been removed, and it appears from the statements of shippers, confirmed in some cases by the reports of our consular agents, that there is a tendency to make them more stringent and irksome. It is sufficiently evident that any assistance which the Government can properly render to such trade, at a time when our home markets are overstocked as at present, should be freely accorded.

A bill providing for a general inspection law of this character was passed by the Senate September 18, 1890, and has been referred to the Committee on Commerce of the House of Representatives. This bill provides for all necessary regulations, and if passed will enable the Secretary of Agriculture to cause the inspection of animals and meats at slaughter, and to give a guaranty of their wholesomeness and freedom from taint of every kind. Such a law is urgently needed and should be enacted without delay

QUARANTINE AND INSPECTION OF IMPORTED CATTLE.

Regulations for the quarantine of neat cattle from the countries not located on the American continent continue to be enforced. The period of quarantine—three months—is regarded as amply sufficient under the regulations to prevent the introduction of disease; and no additional restrictions will be imposed, notwithstanding the fact of the restrictions imposed by Great Britain on cattle from this country, and the further fact that pleuro-pneumonia is much more prevalent and widespread in Great Britain than it ever was here.

There has long been danger of the introduction of foot-and-mouth disease by the importation of sheep, swine, and other susceptible animals that have heretofore been allowed to land without either quarantine or inspection; indeed, this disease has several times been brought to this country by cattle from Great Britain, but it has fortunately been detected in time to prevent its dissemination here. Notwithstanding this fact, our sheep have been excluded from Great Britain for more than ten years, owing to the alleged existence of this disease in the United States, where it is never seen except in British cattle that were affected before landing.

I have concluded that the adoption by this Department of regulations for quarantine and inspection of all neat cattle, sheep, and other

ruminants, and all swine imported into the United States under the authority given to me by the act of August 30, 1890, is necessary for the full protection of our own live animals. Regulations have accordingly been perfected to carry this provision into effect, and it is believed that the result will be not only to fully protect our herds and flocks, but, in view of the assurances to that effect secured from the British authorities, that it will moreover result in the revocation by the British Government of the regulation excluding our sheep from Great Britain. This inspection and quarantine of all cattle, sheep, and swine imported into the country will add seriously to the work of this Department. During the twelve months ending June 30, 1890, cattle were imported to the number of 30,695; sheep to the number of 393,794; but the figures of the Bureau of Statistics of the Treasury Department fail to give the number of swine imported. Increased duties levied under the present law will no doubt greatly diminish the number of animals imported, although during the year just mentioned 3,935 head of cattle and 16,303 head of sheep were admitted duty free, on the ground that they were imported for breeding purposes.

In this connection I would point out that the average value of the 10,865 horses imported for breeding purposes during the year was but $270 each; that the cattle imported for this purpose averaged but $18.60, and the sheep but $7.26, showing conclusively that by far the greater number of these animals were not of such a character as would improve our native stock, and that they could only be sold in competition with the animals produced by our own farmers. The new law provides "that no such animal shall be admitted free unless pure bred of a recognized breed, and duly registered in the book of record established for that breed." This wise provision will no doubt restrict the importation of animals free of duty to those which have special merit and which will prove beneficial to the agricultural interest.

THE SUGAR INDUSTRY.

Encouraging progress has been made within the past year in the development of an indigenous sugar industry. Under the impetus given by the investigations of this Department, improved processes of manufacture have been introduced on many of the more prominent plantations of Louisiana. In Florida large tracts of swamp land suitable for the cultivation of sugar cane have been reclaimed, and the culture and manufacture of cane have already been begun. In Nebraska a large beet-sugar factory, capable of using 300 tons of beets per day, has been erected with the best approved modern machinery, and is now in successful operation. The finest quality of granulated sugar is produced, which finds a ready local market, thus avoiding all expenses of transportation to and from a distant refinery.

A careful study of the soil and climatic conditions of the country favorable to the production of sugar beets has been made, and those localities in the United States best adapted for this purpose have been pointed out. This area includes a zone of territory extending from the Atlantic to the Pacific, with a breadth of from 100 to 200 miles. It includes parts of the New England States, Northern New York, Northeastern Pennsylvania, Northern Ohio, Indiana, Illinois, Wisconsin, Southern Iowa, parts of Nebraska and the Dakotas, and large portions of the Rocky Mountain plateaux and of the Pacific slope. Within these areas it is confidently believed—and this belief has been verified by actual production of good beets—will be found an adequate acreage for the production of sugar on a large scale, and from beets as rich as can be grown in Europe. It is not an idle prophecy to speak of the production of a quantity of beet sugar in the near future sufficient to supply one half or more of all the sugar consumed in the United States.

The investigations in sorghum culture have also been vigorously prosecuted, and the Department will soon be ready to offer to the sorghum growers of the country a few varieties of that plant which have been already developed to a high degree of excellence as sugar producers. At least one sugar factory in Kansas has been operated the present year with profit to the owners, with an output of three quarters of a million pounds of sugar, demonstrating that with the best agriculture, the best soil and climate, and the best machinery, sorghum sugar may be made at a profit.

Under the fostering provisions of the new tariff bill, it is believed that the patient and laborious investigations of the Department will soon bear fruit and result in the production of our sugar at home. To further secure this end I have established three special experimental stations for the scientific study of the problems underlying the promotion of an indigenous sugar industry; one each for sugar cane, sorghum, and the sugar beet. Through these stations the farmers of the country will be taught the principles of the successful growth of the plants producing sugar, and the manufacturer the best methods of securing in marketable shape the products of the fields. With the administrative changes in the tariff law which I recommend, it is my sincere belief that the efforts of this Department to secure home sugar for home consumption will prove successful.

EFFECTS OF RECENT LEGISLATION.

It becomes my duty to call attention in this report to certain provisions under the tariff law which went into effect on the 6th instant, relating to the bounties on sugar from beets, sorghum, or sugar cane grown within the United States. Under Schedule E, paragraph 231, it is provided that the bounty on sugar, according to the polariscopic test, shall be paid "under such rules and regulations as the Commis-

sioner of Internal Revenue, with the approval of the Secretary of the Treasury, shall prescribe." Paragraph 232 provides that to the same officer, namely, the Commissioner of Internal Revenue, sugar producers shall give due notice as to the place of production, equipment, and an estimate as to the amount of sugar they propose to produce in the current or next ensuing year, and that they shall furthermore apply to the Commissioner of Internal Revenue for a license, accompanied by a bond. Paragraph 233 provides that the Commissioner of Internal Revenue shall issue such license; paragraph 234, that no person not so provided with a license, etc., can receive bounty, and that the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, "shall from time to time make all needful rules and regulations for the manufacture of sugar from sorghum, beets, or sugar cane grown within the United States, or from maple sap produced within the United States, and shall, under the direction of the Secretary of the Treasury, exercise supervision and inspection of the manufacture thereof;" and so on throughout the entire Schedule E, relating to sugar, does the law provide that the entire regulation and control of sugar making in the United States shall devolve upon a subordinate officer of the Secretary of the Treasury.

It seems impossible that the law should have been so drafted, save by an oversight. The entire work relating to the development of the sugar industry in the United States, from the chemical supervision of sugar making established in Louisiana to the sorghum and beet-sugar experiments throughout the country, has been, from the first, part of the work of the Department of Agriculture, under the special supervision of its chief chemist. Under the direction of this officer there have been issued from time to time bulletins of the utmost importance to both growers and manufacturers. They are, indeed, the only official sources of information relating to this important industry issued by the National Government; and during the last session of Congress a special appropriation was made by that body of $50,000, to be expended through the Chemical Division of this Department under my direction, in promoting the cultivation of sugar-making plants and the manufacture of sugar. Moreover, the very essence of the supervision necessary, with a view to an equitable award of bounties, namely, the testing of the sugar by the polariscope, is a strictly scientific operation, coming within the sphere of the Chemical Division, and one with which a considerable experience has made the chief and his assistants thoroughly familiar.

If it is really the intention of Congress to withdraw the "supervision and inspection" of the sugar industry from this Department, such intention should be formally expressed, and the efforts of this Department in relation to this important matter, involving the

expenditure of much time, labor, and money, must be restricted to such lines of labor and investigation in connection with this industry as relate directly and exclusively to the sphere of the tiller of the soil. It is perhaps not generally understood that heretofore all the scientific supervision of work done in the various manufactories of sugar throughout the country has been exercised by the Chemical Division of this Department. Officers of this division have been detailed by me for this purpose, and a number of them are so engaged under my orders at the present time. It is unquestionably due to this Department to recognize the fact that whatever improvement has been made in methods of sugar manufacture, and whatever progress has been accomplished in the development of the sorghum and beet-sugar industry, has been due to the scientific investigations conducted under its auspices and the practical application of the results under the supervision of its officers.

Again, under free list, paragraph 482 provides that "any animal imported specially for breeding purposes shall be admitted free." It is further provided, in accordance with a suggestion of my own, that no such animals shall be admitted free unless pure bred, of a recognized breed, and duly registered in a book of record established for that breed. The provisions referred to are followed by the statement that "the Secretary of the Treasury may prescribe such additional regulations as may be required for the strict enforcement of this provision." Even before this Department was an executive department of the Government, its Bureau of Animal Industry had supervision of the importation of live animals into this country, and the head of the Department was held responsible in matters of quarantine of live animals, and for the supervision of the live-stock industry and the contagious diseases of animals. Recent legislation enlarges the powers of this Department, lodging in the hands of the Secretary of Agriculture the control of all importations of animals, whether free or dutiable, imposing upon him the duty of inspecting the same, as he is charged also with the duty of regulating the interstate commerce in live animals and the proper inspection of all live animals exported.

Under those circumstances, the provision I have quoted, making it the duty of another officer to prescribe regulations for the enforcement of the provision admitting animals free under certain conditions, is incomprehensible to me. In section 20 of the said law it is provided—

That the operation of this section—

Prohibiting the importation of neat cattle and hides of neat cattle from any foreign country—

shall be suspended as to any foreign country or countries or any parts of such country or countries, whenever the Secretary of the Treasury shall officially deter-

mine and give public notice thereof, that such importation shall not tend to the introduction or spread of contagious or infectious diseases among the cattle of the United States, and the Secretary of the Treasury is hereby authorized and empowered, and it shall be his duty, to make all necessary orders and regulations.

Inasmuch as there is no officer of the National Government whose duty it is to have authentic information as to the existence of diseases among cattle in foreign countries and as to the contagious or infectious character of such diseases, and the probability of the introduction or spread thereof among the cattle of the United States, save only the Secretary of Agriculture, the provision in question which makes it the duty of another officer to declare officially as to such facts is, to say the least, an instance of glaring inconsistency in the law.

REORGANIZATION.

The act providing the necessary appropriations for carrying on the work of this Department became a law but a few months ago, and until this was done I was naturally much hampered in my efforts to carry out fully and thoroughly the measures indicated by me in my last report as essential to an efficient reorganization of the Department. During the past winter and spring I was obliged to do the best I could in this direction under these discouraging circumstances.

Since the 14th of July, when the appropriation act became a law, I have, with such appropriations as Congress saw fit to place at my disposal, pushed the work of reorganization with all possible energy. Under that act several new divisions were created, but as the work for these divisions had already been duly considered and carefully outlined, and as the persons designed to take charge of them were already in the employ of the Department, their reorganization was effected, I may say, immediately on the passage of the law.

A review of the work of the several divisions, which I now have the honor to lay before you, indicates the activity and energy with which the work of the Department has been pushed; and with a well-deserved tribute to the intelligence and good will exercised by all the members of my large force, in the performance of the duties assigned to them, I will now call your attention to the most salient features of the work of each division.

BUREAU OF ANIMAL INDUSTRY.

I have already alluded in this report to the exercise of the administrative powers of this Bureau and the generally satisfactory results which have followed, as well as to the additional powers which are in my opinion needed to make the work absolutely efficient.

INVESTIGATION OF DISEASES.

The scientific investigation of the communicable diseases has been carried on for the purpose of elucidating the many points in connec-

tion with the cause and nature of these maladies which must be understood before they can be economically prevented or eradicated. The diseases to which most attention has been given are hog cholera and Southern fever of cattle. With both, discoveries of great importance have been made which are not only of value from a scientific point of view, but which promise important results in the way of prevention and treatment, and will accordingly be treated at length in the report of the Bureau of Animal Industry.

A thorough knowledge of animal plagues is becoming more and more necessary, both because of the great increase in the number of animals in the country and the multiplication of the transportation routes by which contagion may be carried, and also because of the recent legislation already mentioned looking to a Government guaranty that the animals shipped abroad and those from which our meat products are obtained have been unaffected by disease. The excellent results which have already been reached with pleuro-pneumonia and Texas fever demonstrate the possibility of controlling and even eradicating the most virulent diseases when our knowledge of them is sufficient to indicate the proper measures. That the most destructive diseases of swine and other animals will be ultimately controlled or eradicated is almost certain, and to hasten this result the scientific investigations should be maintained and made more comprehensive.

A short time ago, I regret to say, there was an announcement made under the authority of a State official, referring to an outbreak in a Western State, which was characterized as "foot-and-mouth disease." Issued under such auspices it was given extensive publication, but fortunately my attention was called to it at the start, and I immediately telegraphed the governor of the State in question, requesting him to do all that was in his power to repress the spread of a rumor which I felt sure must be groundless, and announcing my intention to have the matter immediately investigated by a competent authority. I at once dispatched one of our veterinary inspectors to the spot and received from him a report confirming my anticipations to the effect that it was not the disease known as "foot-and-mouth disease," and, furthermore, that it was not a contagious disease at all. Immediately on the receipt of this reassuring report, I cabled the facts to our consul-general's office in London, in order that he might make it public there, the unfortunate rumor to which I refer having already been reproduced in British journals.

I desire to emphasize here the danger of giving out statements of this kind without a thorough investigation. Immediate communication with this Department will always find me willing to co-operate in an investigation of this kind, and, until the exact facts are ascertained beyond a doubt, no statement alleging the existence of a dangerous contagious disease should be given to the public. It is

no exaggeration to say that the losses to our cattle growers from unfounded rumors of such diseases have been infinitely greater than the actual losses occasioned by the diseases themselves.

COLLECTION AND DISTRIBUTION OF INFORMATION.

The information obtained from year to year by the scientific investigation of diseases must necessarily form but a small portion of the existing knowledge on the subject of disease, and must be used in connection with what has been previously acquired in order to give satisfactory results. For this reason I have deemed it of great importance that reliable reports should be issued, treating systematically of the common diseases of animals with special reference to prevention and treatment. Taking these as a basis for comparison with the results of investigations issued annually, the farmer will be enabled at all times to obtain full information in regard to any disease with which his stock may be affected.

The first report of this series on the Animal Parasites of Sheep has recently been issued. and a second report on the Diseases of the Horse is now in press. Other volumes are in preparation and will be issued as rapidly as possible. The favor with which the announcement of these publications has been received shows that they will supply a variety of useful knowledge which has been greatly needed by the agricultural community.

Various lines of investigation are being vigorously prosecuted with the design of showing the actual condition, means of improvement, and future prospects of various branches of the animal industry. A full report on the Sheep Industry is in preparation, well advanced towards completion, and will probably form the first volume of this series. Reports on the American Trotter and the Thoroughbred Horse of the United States will be ready for the press at about the same time. This brief statement of the reports now nearly completed will serve as an indication of the character and scope of this section of the work of the Bureau of Animal Industry.

Last February I received an invitation to attend an interstate convention of cattlemen, to be held the following month at Fort Worth, Texas. Though unable to attend, I was impressed with the character and scope of the work indicated in the call for this meeting, and detailed a special agent of this Department to be present. I also sent a stenographer from this Department, with instructions to take a full report of the proceedings for my information. One of the subjects which was thoroughly discussed at the important convention in question, at which thirteen States were represented, was the urgent necessity to cattle growers for more extended information on the subject of the cattle supply of the country, the condition of the cattle markets, and the relation of quality to price in the cattle marketed. I have given this subject considerable attention, have

invited an exchange of views on the subject from prominent cattlemen, and have concluded that an earnest endeavor to secure information of the kind desired must be made by this Department through the Bureau of Animal Industry and its agents. It is merely carrying out the conviction which I have frequently had occasion to express elsewhere, that the peculiar circumstances of our agricultural people and their lack of facilities such as are enjoyed by people whose occupations require them to live in cities, within easy access of all centers of information relating to their business, make it the imperative duty of this Department to supply this lack as far as possible, and I have determined that an earnest effort in this direction shall be made during the coming year.

DAIRY AND POULTRY INTEREST.

In my last report I announced my determination to establish in the Bureau of Animal Industry a special division devoted exclusively to the service of the dairy interest. The act of appropriation, with the changes made in the appropriation for the needs of this bureau, making it possible to carry this determination into effect, was passed so lately that the thorough organization and equipment of an important division of this character has not yet been possible. The present encouraging condition of the dairy interest, its vast extension throughout this country, and the general appreciation of the necessity for the successful conduct of the dairy business, of the strict application to the feeding of dairy cattle of the most scientific principles, and of the application to the business of perfect methods, make necessary the establishment in this Department of a division which shall be in these matters the natural leader. Such a division should moreover be able to extend material benefit to the dairy interests of this country by lending its aid to the extension of our export trade in dairy products and to the development of the manufacture at home of every dollar's worth of dairy products which we consume, an object which will be still further facilitated by the recent increase in the duty on cheese, a product which constitutes almost our entire dairy import.

Regarding the poultry interest, I am inclined for the present to place it in the special charge of the Dairy Division. Even though it may not be essential that this interest should be represented at present by a special division, the magnitude of the interest requires that some one division be charged with its supervision. The poultry products of this country represent in the aggregate a vast sum; and the industry is one which exists, or should exist, on every farm in this country, and which, consequently, interests a larger number of the constituents of this Department than any other single industry. In this connection, I congratulate our poultry raisers on the recent change in the law, which instead of admitting imported eggs free,

now levies on them a duty of 5 cents per dozen. The large imports of eggs into this country in past years, which it seems have come not only from our neighbors in Canada but even from across the ocean, amply justify the imposition of this duty.

DIVISION OF CHEMISTRY.

A review of the work of the Chemical Division during the past year shows that it has been carried on with diligence and success. New and commodious quarters have been acquired for the use of the division, and many mechanical facilities have been provided which it was impossible to find in the old quarters in the basement of the main building.

Work in connection with the adulteration of foods has been heartily sustained by Congress, and an increase in the appropriation has been made therefor. This is a work which should have the sympathy of every legislator and the help of every honest man. The adulteration of human food is an evil whose proportions are growing, I am sorry to say, from year to year. It is an evil destined to undermine and destroy health; and its practice not only interferes with the sale of products honestly manufactured, but also casts discredit upon our goods in foreign countries, corrupts morals, and places a premium upon dishonesty. I hope to be enabled, through the Chemical Division, to analyze specimens of every product placed upon our market in competition with pure goods and products of the farm, and the co-operation of Congress in these efforts is earnestly solicited. Investigations during the past year have related particularly to the adulteration of tea, coffee, chocolate, and other table beverages. These results are now nearly ready for delivery to the printer.

These investigations show that the adulteration of such articles is not very extensive, and, except in the case of tea, is easily distinguishable. The most frequent one is the introduction of substances to give additional weight, such substances as will attach themselves readily to the leaves and yet not be easily distinguished by the eye. These substances are mostly of a harmless character, although some of them have been found to be deleterious. In the case of coffee the chief adulterations have been found in the ground coffees, the difficulty of adulterating the berry, whether roasted or unroasted, being so great as to almost exclude this kind of fraud. With the green berry, the chief adulteration seems to be in exposing it to a moist atmosphere that it may absorb moisture and thus increase in weight; but this is a species of fraud which is easily distinguished, since the simple drying of the berry and the estimation of the water contained therein is sufficient to determine whether or not it has been thus exposed.

Extensive investigations have also been made in regard to the adulteration of sugar, molasses, honey, and confections, and the publication of this work will speedily follow that of the work on the adulteration of table beverages.

A thorough study of the materials which prevent the crystallization of the sugar in sorghum juices has also been made, these substances have been identified and studied, and the best methods of removing them from the sorghum juices have been investigated.

Coupled with this work has been the continuation of the experimental station work for the development of varieties of sorghum which are as free as possible from these deleterious substances, and containing as high a percentage of sucrose as can possibly be obtained by years of patient selection of seed and careful cultivation of the cane. Some remarkable results in cultivation of this kind are now on record.

In 1889 four varieties of cane were studied for thirty-five days, giving in that period an average of 14.15 per cent. of sucrose in the juice, 1.15 per cent. glucose, and having a purity coefficient of 77.5. The present year seven varieties of cane, for the same length of time, showed an average of 14.48 per cent. sucrose, .77 per cent. glucose, with a purity coefficient of 76.40. The best varieties of cane this year showed, for fifty-one days, from August 25 to October 15, 15.48 per cent. sucrose, .51 per cent. glucose, with a purity coefficient of 78.36.

It is proposed to continue these culture experiments for the purpose of developing and introducing all varieties of sorghum cane which give any promise whatever of becoming useful. In all, the Department has experimented with about 800 varieties and subvarieties of cane. Many of these, on investigation, proved to be duplicates of others which had come to us under separate names. From this extensive list, after three years of careful investigation, all have been eliminated except ten or twelve distinct varieties which possess the essential qualifications of sugar-producing plants, viz., high sucrose content with a low content of other substances. Work will be continued with these selected varieties until their excellent qualities are rendered permanent by continued selection and by improvement due to careful cultivation. It is believed that the sorghum plant will then be able to compete successfully with the sugar cane and the sugar beet, but only in those localities where soil and climate are best suited for the production of the sorghum plant in its highest perfection.

The investigations so far completed show that the localities in which sorghum can flourish are confined to the semi-arid region of the country, notably beginning in Central Southern Kansas and extending southward indefinitely. The investigations have also shown that sorghum of excellent quality can some seasons be pro-

duced in other parts of the country, but the uncertainty of suitable climatic conditions would seem to render it advisable to attempt the production of sorghum for sugar-making purposes only in the localities indicated.

Investigations by the Department in respect to the production of sugar from the sugar beet have also been of the most extensive nature. During the early spring 5,000 packages of sugar-beet seed of the most approved varieties were obtained from European growers and sent to all persons in the country who had applied for them. Arrangements were also made by which the beets, after maturity, could be sent to the Department for analysis. As a result of this arrangement beets have been received from about one thousand different localities in all parts of the country, and these have been analyzed in the laboratory. The results of the analysis are, for the most part, extremely favorable, especially with those varieties which have come from the northern and central portions of the country. It is not uncommon to find beets containing 15 per cent. of sugar, while in exceptional cases the percentage of sugar has risen as high as 20. We have also found many beets of a strictly typical character, combining a perfect shape with the proper weight and a high content of sugar. A typical sugar beet is conical in shape, smooth in its external contour, with a white, solid interior, weighing about 1 pound, and having a content of sugar of about 14 per cent. Many samples of such beets have been received, showing that it is possible to produce in this country sugar beets of the highest type.

In Bulletin No. 27 are given the results of a careful study of the soil and climatic conditions of the country suitable to the production of sugar beets, and a map has been prepared showing a zone within which the most favorable results will probably ensue from the cultivation of the sugar beet. A large beet-sugar factory has been erected at Grand Island, Nebraska, equipped with the most approved modern machinery, and this factory is now working sugar beets at the rate of 300 tons per day. There is every reason to believe that the encouragement which has been extended to the sugar-beet industry, by the investigations of the Department and by act of Congress, will result ere long in the establishment of many additional sugar factories in those portions of the country which the data obtained by the Department show to be best suited for the purpose. When it is considered that 250 beet-sugar factories of the size and capacity of those now in operation in California and Nebraska will be sufficient to make one half of the total sugar consumed in the United States, it is not idle to expect that in the course of a few years a large proportion of the sugar consumed in the United States will be made therein from the sugar beet.

Further investigations of the Chemical Division have had relation to matters more specifically connected with the agricultural experi-

ment stations and the best methods of analysis to be used therein. Investigations have been made of these methods in the laboratory, and they have been carefully compared with other methods, so that the best could be secured. In this work the co-operation of the agricultural chemists throughout the whole country has been enlisted in an organization known as the Association of Official Agricultural Chemists, whose annual conventions are held in Washington under the auspices of the Department of Agriculture and whose proceedings are published as bulletins of the Chemical Division. Bulletin No. 28 of this division, containing the proceedings of the association meeting held in August, is now ready for the press.

DIVISION OF STATISTICS.

The operations of the Statistical Division have been replete with activity in various directions. The necessity of statistics in the work of legislation is becoming more and more imperative, as attested by the demands upon this office during the extended session of the present Congress. The discussion of industrial and economic questions in the halls of legislation, in polemic discussion, in literature and journalism, makes constant demand upon the resources of the Statistical Bureau for the facts of production and distribution, prices of products, wages of labor, development of resources, and status of agriculture.

The year has been somewhat peculiar in its statistical record. An abnormally mild winter, characterized by verdure and vegetable growth until late in the season throughout all but the higher latitudes, was closed with a period of low temperature and frosts, which extended southward to the orange belt of Florida. The effect of conditions so extreme was injurious to all the winter grains and to all the orchard fruits, forecasting the reduction in area of winter wheat which followed, the unequal rate of yield for the breadth remaining, and the unexampled dearth of nearly all kinds of fruits. Even the Pacific coast had an exceptional experience, consistent in its proverbial unlikeness to Atlantic coast conditions, for while the country from the great mountains to the eastern seacoast was singularly mild and summer-like, the Pacific slope was cold and stormy, with heavy rainfall and an unusually late spring.

The spring weather of the East was unfavorable to early planting, being too cool and wet at many points. These conditions were favorable to the hay crop, which is very valuable everywhere, and in the South becoming vastly more important every year as the improvement of farm animals progresses in that region, promising to make stock growing a very prominent rural industry of the cotton belt, which is in many respects peculiarly adapted to profitable extension of the various forms of animal industry.

The great arable crop of the country, corn, has had an unfavorable development. Starting in July with a condition expressed by the average of 93.1, which was less promising than the record of the previous year, but by no means discouraging, the effect of drought reduced the average in sixty days to 70.1; and on the 1st of October, when the crop was matured, the record stood at 70.6, against 91.7, indicating a prospect for 23 per cent. decrease in the rate of yield compared with that of last year. This foreshadows a reduction of something like half a billion bushels of corn. Still there is a fragment of last year's crop remaining, and there will be ample supplies for consumption of high-priced corn. The amount consumed depends much upon price, and the export demand is influenced far more by this consideration than the domestic consumption.

The winter wheat crop was reduced by spring frosts, and the spring wheat in its drier areas by drought, so that the average condition when harvested was expressed by 75.5, against 87.5 last year, indicating a yield materially less than that of 1889, upon a reduced area. The oat crop has met with serious disaster, reducing its product more than 200,000,000 bushels. It has also been a year of partial failure of the potato crop. The reports of condition have been growing worse since July, and as the time of harvesting approached the yield was still further reduced by the prevalence of rot. The Southern crops are generally above an average in production. The cotton crop of last year was the largest ever grown and brings a good price, and the prospect is now good for another large crop. The sugar product is also large, probably the largest grown for many years. Rice, tobacco, and vegetables have generally yielded well, and among the results is a high degree of prosperity in nearly all branches of Southern agriculture.

The despondency which was caused by the low prices of the beginning of the year has already been measurably dispelled by the advance in agricultural values, and good grounds exist for the belief that our farmers are entering upon a new era of profitable culture and general industrial prosperity.

DIVISION OF ENTOMOLOGY.

Though the year has not been marked by any very serious insect injury of a general character, the work of this division has been steady and unremitting. During the past few years the boll worm of cotton (*Heliothis armigera*) has been a source of more than usual damage to the cotton planters, particularly in Texas, Southern Arkansas, and parts of Mississippi and Louisiana, doing more harm than even the cotton worm (*Aletia xylina*). The edition of the fourth report of the U. S. Entomological Commission, treating of the cotton worm and boll worm, is exhausted, and there has been a general

demand from the States interested for a supplementary investigation of the pest. Congress appropriated a small sum for this purpose, and the investigation has been begun. Agents of the division have been stationed at College Station, Texas; Pine Bluff, Arkansas; Holly Springs, Mississippi; and Shreveport, Louisiana; and the work of study and practical experiment has been apportioned so as to bring about the best results. The appropriation became available too late in the summer for efficient work, but the work this season will prepare the way for more thorough work next year, and if there is any possible way of giving our planters more effective and practical means of overcoming this enemy than those now at command, I have confidence that the way will be discovered.

During May there was a local outbreak of the army worm (*Leucania unipuncta*) in certain portions of the State of Maryland, and an agent of the division was sent to investigate it. There were some features about this outbreak that appeared abnormal, and the entomologist will consider it in his report in connection with another insect that is often mistaken for the army worm and which is much subject to an epidemic disease, a fact which acquires importance because of the possibility of artificially conveying this disease to the boll worm.

During July and August alarming rumors of the destructive appearance of the Rocky Mountain locust, or western grasshopper (*Melanoplus spretus*), were received from Idaho and Utah, and an agent of the division was sent to investigate them. He found that the locust in question was not the western migratory species, but a comparatively local form known as *Camnula pellucida*, information most reassuring to farmers in the Mississippi Valley. The means adapted to combating this last mentioned locust are identical with those which were found efficacious in the case of the first mentioned. The report of the Entomological Commission, containing the necessary instructions, is unfortunately out of print; but for the benefit of farmers situated in the district threatened by the present pest, I have directed the entomologist to prepare a summary of these instructions for distribution throughout the section of country subject to the present visitation.

Further experiments have been made with the use of hydrocyanic acid gas under tents as a remedy for the red scale. In my last report the statement was made that the cost of this remedy had been greatly reduced by experiments made by one of the California agents, and further experiments have developed means by which the process may be easily rendered more efficacious and the expense still further reduced.

The horn fly of cattle, which attracted so much attention last year, seems to have been much less abundant during 1890, and complaints from stockmen have been comparatively rare. Observations con-

firmatory of the results recorded in my last report have been made, and late fall and winter observations show that this insect hibernates in the preparatory state in the ground.

The question of the damage of the grape by phylloxera in California has been taken up, and certain vine-growing regions of the State have been visited by an agent, who is making tests and observations.

The division has been appealed to in reference to the possible danger of the importation of the destructive Florida scale insect into California, a matter which has attracted a great deal of attention the past season in the latter State. It seems that frequent accidental importations of these scales, particularly of the purple scale, the long scale, and the chaff scale, have been made; but in no case have the insects become destructive. It is therefore argued by many that the climate of the Pacific coast is not favorable to their increase, while others hold opposite views and are much alarmed. The entomologist is of the opinion that, while there are some grounds for the former belief, we can not exercise too much care in preventing the carrying of these destructive scale insects from one section to another. I have therefore been particularly careful to have the plants received from foreign countries and to be shipped to the different States carefully disinfected before such shipment, as I am very anxious that the Department shall not be the means of further disseminating such noxious species. I earnestly recommend that similar precautions be taken by all nurserymen and horticulturists shipping plants to other States.

In view of the success that has attended the importation of the Australian lady-bird to prey upon the fluted scale in California, public attention has been specially drawn to this manner of destroying injurious insects through the instrumentality of their natural enemies, but success in any instance is not likely to follow without the most complete, thorough, and intelligent direction. The entomologist, fully realizing the importance of this question, has made various efforts during the year, so far as they can be made with the assistance of foreign correspondents equally interested in the subject, to import desired species, and to reciprocate by sending others abroad.

The increased appropriation to this division will justify renewed attention to the subject of bee culture, and plans are being formed to carry on whatever investigations will tend to advance this important industry. The investigations already made under direction of the entomologist had for their object the control of the fertilization of the queen, whereby bee keepers would be able to improve the disposition and the honey-producing qualities of their bees by selection, in the same manner in which the stock breeder and the fruit-grower have for so many years so successfully improved our domes-

tic products. There is reason to believe that this can be accomplished with reference to the bee; but there are many other ways in which the Department can help the bee keeper in investigations on a scale which neither individuals nor associations can afford to pursue. This is especially true in reference to the study and introduction of bee plants from sections of the country or other parts of the world where they are valuable into sections where they are not yet known. This applies also to the introduction of bees known to have desirable qualities, as, for instance, the *Apis dorsata* of Ceylon.

Many other insects of less importance have been carefully studied and figured, notably the rose chafer, concerning which a complete article has been published in the periodical bulletin of the division. The publications of the division have occupied more of the time of the office force than usual. The issue of Insect Life, the periodical bulletin, has been continued, and most encouraging comments concerning the usefulness of this publication are constantly received.

DIVISION OF MICROSCOPY.

The following is a brief abstract of the work upon which the Division of Microscopy is engaged for the current year: Original investigations in the interest of pure food stuffs, including medicinal and food oils and condiments. In food stuffs the skillful use of the microscope is constantly demanded to meet the new methods and combinations practiced in the adulteration of butters, lards, and branded substitutes for butter and lard, as well as in the examination of the various other food products. A microscopical examination of certain lard compounds in relation to the lard bill of the Fifty-first Congress was made by this division for, and at the request of, the House Committee on Agriculture.

The study of economic textile fibers is also a part of the work of the year. The various structural characteristics of textile fibers, which represent their felting properties, in respect to which they greatly differ, will be illustrated.

A further and more comprehensive illustration of our native edible mushrooms, as well as of poisonous varieties, and of those which may be classed as doubtful, is in progress as part of the year's work.

DIVISION OF ECONOMIC ORNITHOLOGY AND MAMMALOGY.

During the past year the work of this division has been continued in the two lines of research mentioned in previous reports.

(1) The work on geographic distribution of species has received as much attention as the means at the command of the division would permit, and considerable progress has been made both in the study of the faunal areas of the country and in mapping the distribution of species.

A report of the work done in Arizona during the summer of 1889 has been published as North American Fauna, No. 3. It gives in detail the results of a biological survey of about 5,000 square miles in the northern part of the Territory, and is accompanied by accurate maps of the forests of the region. The practical scientific value of such a survey is self-evident, and it is hoped that the division may be enabled to extend this work to other and larger areas.

The study and mapping of faunal areas—those fitted by nature for the existence of peculiar associations of animals and plants and consequently for the production of certain crops—has progressed far enough to warrant the issue of a provisional map. Such a map, showing by different colors the principal life areas of North America, has been prepared and accompanies North American Fauna, No. 3.

In order to obtain more complete data respecting the breeding range of various species of birds, a special schedule was prepared and sent out early in the year, and already reports have been received in reply from nearly four hundred localities. These reports contain much valuable information, which is being tabulated and mapped as rapidly as possible.

The most important field work accomplished during the present year has been that done in the Salmon River Mountains in Idaho, under the personal supervision of Dr. Merriam, chief of the division, assisted by Mr. Vernon Bailey and Mr. Basil H. Dutcher, field agents of the division. This work, which is still in progress, has already brought to light many facts of economic and scientific value concerning this almost unknown region, and has resulted in the discovery of several species new to science. Important work has also been carried on in the arid regions of the West, especially in Texas, Wyoming, Utah, and Washington; in the latter State an effort is being made to determine the northern limits of the "basin region."

(2) The economic work of the division, that devoted to the study of species directly injurious or beneficial to agriculture, has been mainly confined to investigations connected with the preparation of four distinct bulletins, namely, (*a*) an illustrated bulletin on hawks and owls, now almost completed, which, it is hoped, will be ready for distribution soon; (*b*) a bulletin on the gophers of the Mississippi Valley, on which work has been continued during the year and much valuable information secured concerning the distribution and ravages of the several species; (*c*) a bulletin on the common crow, already far advanced, and (*d*) a bulletin on crow blackbirds, now well under way. In connection with the work on these bulletins more than eight hundred stomachs have been examined during the past year, while about two hundred more, mainly those of bobolinks and meadow larks, have been examined in response to special requests for information as to the food of these birds.

A little time has been devoted to the collection of published notes

by other workers in this little-known field, but the records are so few and so widely scattered that as yet only a beginning has been possible.

In connection with the stomach examinations the utility of the reference collection of seeds has been demonstrated almost daily, and although very considerable additions have been made during the year, this collection is still lamentably incomplete. The facilities for the determination of stomach contents have been materially increased and a competent biological clerk has been added to the force of the division.

More than 4,000 specimens have been sent in for identification by field agents and others, and a large and increasing correspondence has been conducted since January 1, 1890

DIVISION OF FORESTRY.

Although there is evidence of a growing appreciation throughout the country of the importance of the interests which this division is designed to serve, there is still need that the scope and character of its work be explained and illustrated. The day when forest planting and the application of scientific principles to the management of our natural forest areas will be generally recognized as a necessity, is certainly approaching. While our forest resources are still immense, signs of approaching exhaustion in certain directions are already apparent. Carriage timbers especially are becoming scarce. The scarcity of walnut has long been known, and trade papers are beginning to discuss the difficulty with which first-class white-pine stock can be secured and to note the abundance of culls in the market, a sign that this staple resource, often represented as inexhaustible, must have been considerably reduced.

Without, therefore, entertaining alarming apprehensions of timber famine in the near future, it is a wise policy to keep watch over our forest resources, to show how unnecessary waste can be avoided and the means of economy developed, and to teach those principles by the application of which the natural forests may be so utilized as to recuperate and reforest themselves with valuable timbers, and also to teach how to create new forests artificially. It is the duty of this division, furthermore, to point out the consequences upon water and soil conditions of imprudent and undue deforestation. Although better endowed than formerly by the appropriations for the current year, the Division of Forestry is not yet equipped for field work, or, indeed, for any but scientific investigations that can be carried on in the office or laboratory, or by studies in the natural forests.

The two lines of investigation which will continue to be foremost, and for which the present appropriations insure more effective prosecution than formerly, relate to the life history of our important

timber trees and to studies into the relations of the quality of timber to the conditions of its growth. Monographs dealing with the former subject are in hand for publication during the coming winter. The latter investigations will require careful selection of study material, laborious laboratory work, and a large number of tests, and promise to afford results of marked interest to the forester and of great practical value to the engineer, the builder, and indeed to every worker in wood.

During the year there has been published in the interest of forest conservation a very exhaustive report on the experiences of the world in regard to metal ties. This publication is full in mechanical detail, and will serve, it is hoped, to stimulate our railroad managers to give further trial to this substitute for wood material, since it is said to be of improved efficiency and ultimately most economical. Whenever it has been practicable, the chief of the division has been detailed to attend the various forestry conventions and other meetings where it has been believed that interest in forestry matters might be stimulated or advanced.

To accompany distribution of tree seeds, which, to satisfy the demands of the law, is made in small quantities proportionate to the appropriation, a circular giving detailed instructions for handling the seeds was prepared and distributed. It is thought best to restrict the distribution of plant material, as far as possible, to such kinds as are not readily obtainable, or to such as for some other reason are not likely to be tried by the would-be planter, and to engage the experiment stations in the trial of new species rather than leave this work to inexperienced hands. Excepting an importation of Austrian osier rods, which were sent to the experiment stations, only native seeds have been distributed.

RAINFALL EXPERIMENTS.

An amendment to the act of appropriation for this Department was adopted at the last session of Congress placing at my disposal the sum of $2,000 "for experiments in the production of rainfall," it being understood that such experiments were for the purpose of ascertaining whether such a result could be attained by the use of explosives. The difficult and problematical nature of these experiments, and the necessity of undertaking them only under the direction of a person possessing thorough qualifications for conducting the work, has made it thus far impracticable for me to give the matter proper attention. The experiments will, it is expected, soon be inaugurated.

DIVISION OF BOTANY.

As stated last year, two distinct lines of research are carried on by this division—the scientific and the practical. Under the first, gratifying progress has been made in the collecting, classifying, and

mounting of plants growing in all parts of the United States, as well as of others secured by exchange or otherwise from foreign countries.

The herbarium of the Department of Agriculture has become of national importance and of great money value, and some of its parts could never be duplicated if lost or destroyed. Its location in the Department building, which is not fireproof, is a source of great anxiety, not only to those who have charge of it, but to the scientific world. The American Association for the Advancement of Science at its last meeting passed a strong resolution urging the Department of Agriculture to furnish fireproof quarters for it.

The Department has lately commenced the publication, in a special series, of the information which it is enabled to gather from study and comparison in the herbarium. This information is embodied chiefly in scientific papers, designed more especially for botanists, and intended to supplement the more practical work of the bulletins. The special series is not a periodical, but numbers are issued as often as sufficient matter accumulates. Three numbers have already been distributed. Nos. 1 and 3 relate to the flora of Southern and Lower California, and No. 2 is a catalogue of Texas plants, which is preliminary to a manual of the flora of that State soon to be published by this Department.

In the collection special note is made of all economic plants. So far as concerns forage plants, bulletins are issued, illustrated by plates, describing their characteristics and value for forage purposes, and setting forth the soils and climate to which they are adapted. During the year two such have been issued, one a new, revised edition of the "Agricultural Grasses of the United States," the other, Bulletin No. 12, entitled "Grasses of the Southwest." Both bulletins have received the highest commendation from farmers and from botanists. They exemplify in the best sense the value of scientific work applied to practical uses.

The experiments undertaken by the Division of Botany with a view to increase the grass production of the arid lands of the West have thus far demonstrated that a decided improvement in this matter is practicable; that the introduction of certain methods of cultivation and of certain forage plants not before used renders possible great advance in the grazing industry of those regions. Congress at the last session, appreciating the importance of the experiments, increased the appropriation therefor, to enable this Department to arrange with all the Western stations for co-operative experiments under our supervision. The chief of the division has about completed an extended tour of the West and South, made for the purpose of arranging the plan of the work and more carefully studying the conditions of soil and climate. The operations at the Government grass station, at Garden City, Kansas, have been very satisfac-

tory, and for that locality the results have been fully equal to our expectation.

DIVISION OF VEGETABLE PATHOLOGY.

Since my last report Congress, in accordance with my recommendation, has made the Section of Vegetable Pathology a division, and it is now thoroughly organized and equipped with an efficient corps of workers in both the field and the laboratory.

A special effort has been put forth during the past year to make the field work as thoroughly practicable as possible, and with this end in view the chief and several of his assistants have spent considerable time making experiments which I believe to be of great practical value. To show the importance of this work I will cite the case of one series of experiments personally conducted by the chief, the results of which are based on very careful records. The remedies used were those whose efficacy have been established by this division, and the object of treatment was a large nursery whose proprietor had offered his entire stock to the Department for experiment. This work extended over two years. The expense involved was a little over $125, and the amount saved was $5,000.

This division was the first agency in this country to introduce the use of fungicides for grape diseases, and it is estimated as a result of its work that nearly five thousand grape growers in all parts of the country treated their vineyards for mildew and black rot in 1890, and the amount of fruit saved in this way will vary from 50 to 90 per cent. of the crop.

In addition to the foregoing, experiments in the treatment of pear, apple, quince, and numerous small fruits have been conducted in New Jersey, Maryland, Virginia, Wisconsin, and Missouri. The diseases of other crops, such as cotton, tomatoes, potatoes, etc., have been under treatment in numerous widely separated localities, each of which was selected as being particularly adapted to the work in hand.

The laboratory work has been pushed forward with vigor, the principal subjects under investigation being peach yellows, the California grape disease, pear blight, cotton diseases, a bacterial disease of oats, and the so-called "rots" of the sweet potato.

The laboratory investigations of the California grape disease have been mainly in the line of bacteriological study of diseased parts of the vine, supplemented by inoculation experiments, with a view to determining the contagious and non-contagious nature of the malady. Numerous facts bearing on this subject have been accumulated, and these will be shortly embodied, together with a result of the field observations and experiments, in a report soon to be published. In May of this year the special agent engaged in this work

asked and was granted leave of absence without pay for six months, in order that he might visit France, Spain, Italy, and Northern Africa, in search of information that will aid him in his work.

For many years the vineyards of these countries have been ravaged by a disease which, according to the published account, is very similar to the one in California. It was claimed that within the past two years the disease had almost entirely disappeared from certain portions of Italy, and it was principally to get some definite information in regard to this matter that the agent desired to personally inspect the European vineyards. It is hoped that his investigations will enable him to throw some light on the best means of combating the California trouble, which has already devastated thousands of flourishing vineyards, causing losses almost beyond calculation.

The peach-yellows work is being prosecuted with vigor along practically the same line followed last year. Some important results bearing on the treatment of this disease have been obtained, but as yet they are not sufficiently conclusive to warrant their publication.

The publications and correspondence of the division have assumed such proportions, that to give them the attention they deserve requires about one third of the time of the regular office force. Two special bulletins and four numbers of the Journal of Mycology have been issued since my last report, and the fact that the editions of these are now entirely exhausted is, I believe, a sufficient guaranty of the interest in the work.

DIVISION OF POMOLOGY.

The development of the fruit industry throughout the country and in parts of the country where not long since it was thought no fruits could be grown, has been steady and encouraging. It must not be forgotten in estimating the value of pomological work in the United States that we Americans pay to foreign fruit growers more than $20,000,000 per annum for fruits and nuts which we import. I am convinced that one of the ultimate rewards of scientific pomology will be to see very nearly the whole of this vast sum turned into the pockets of American fruit growers, so wide is the range of climatic variation in different sections of our vast country. To accomplish this result necessitates a special study of and experiment in the study of fruit culture; and it is my hope that the Pomological Division of this Department will contribute an important share to this great work.

Special agents have been appointed to obtain information regarding fruit culture in their respective localities, and to report to the pomologist as to their wants and resources. A system of reciprocity between the division and the various national, State, and local societies of a pomological nature has been inaugurated. The identifica-

tion of fruits sent from all parts of this country is becoming more and more useful as a part of the work of this division, and during the past year there has been a very great increase in the number of samples sent for this purpose. It is evident that this portion of the work of this division is highly appreciated by the fruit growers of the country.

I am glad to be able to state that in pursuance of the work of this division, which involves the effort to introduce foreign and untried varieties and species of fruits into this country from abroad, a successful importation was made during the year of the date palm from Egypt and Algeria. Sixty-three trees, representing eleven of the choicest varieties, were received and were found on arrival to be without exception in good condition. This is the first instance of the successful introduction of rooted suckers of any variety of the date upon this continent, a notable event in the pomological history of the country. Their transportation has frequently been attempted, but the plants have never survived the voyage. There are good grounds for anticipating their successful introduction into the arid regions along our extreme southwestern border.

The division has in course of preparation a special report upon nut culture, and it will be based upon the practical experience of those who have already given this subject attention, and such information and advice will be given as may prove of benefit to those who desire to engage in it. Many choice varieties of wild nuts, especially of the chestnut and pecan, have already been discovered in the course of the investigation of the subject, and these will be obtained and placed in the hands of careful experimenters. Choice kinds of the filbert will also be brought from England and placed where it is likely they will succeed in this country.

One of the important features of the work of this division is an investigation of our wild fruits. This investigation should be more thorough than the means at hand enable me to make it, but no field of pomology is more promising of good results than this, and I trust that by enlisting in the work the cordial co-operation of the various experiment stations throughout the country much good may be accomplished even with the limited means on hand.

SILK SECTION.

I stated in my last report that, in regard to silk culture, the real question to be determined as to the possibility of establishing this industry in the United States is that which concerns the reeling of silk, the conversion of the cocoons into a marketable thread.

While I have looked for assistance in the solution of this problem to the improvement of machinery for reeling silk, I have nevertheless become quite convinced that, even with such machinery per-

fected, it would be necessary for manufacturers to have some encouragement, either in the shape of a duty on imported raw silk or a bounty for such as might be produced in the United States. The importance of this subject and the desirability of establishing such an industry are beyond dispute, and, as though to strengthen the claim on behalf of home-grown silk, we find a great increase, nearly 25 per cent., in the imports of unmanufactured silk during the last fiscal year over the preceding one; the imports of this product for the fiscal year ending June 30, 1889, being in value $19,333,229, and for the fiscal year ending June 30, 1890, $24,331,867. Under those circumstances I confess that it would be a source of great regret to me to see the abandonment of all efforts looking to the establishment of silk raising in the United States, but I can not but reiterate my conviction that to all the improvement in mechanical devices which American ingenuity can bring about must be added the benefit of legislative encouragement. Should some bill embodying this idea become a law during the coming winter, it will afford me great pleasure to be the instrument for executing it and creating for this industry a brighter outlook than at present exists.

TEXTILE FIBER INDUSTRIES.

The fiber investigations commenced in 1889 have been steadily pursued with encouraging results. Much valuable information has been collected showing the present status of different branches of the fiber industry in this country and in Europe, a portion of which has already been given to the public in Bulletin No. 1 of the fiber series. Since the beginning of the year nearly 400 specimens of fibers and fiber plants have been received, many of them from farmers and others seeking information regarding possible new fiber interests, or exhibiting to the Department results in cultivation, preparation, or manufacture of known fibers.

Among the examples of American flax received by the Department are several fine samples grown in Wisconsin, Minnesota, Iowa, and on the Pacific coast, one of which, from the first named State, is declared by a leading manufacturer to be "good enough for even fine linens." A fine sample was also received from Texas. A beautiful example of linen thread, grass-bleached in New Jersey, demonstrates that this branch of the linen industry can be carried on in the United States as successfully as in Europe; while the entire linen series proves conclusively that even fine flax, in any quantity, can be produced in this country with skill and careful culture. The new tariff law raises the duty on dressed line from 2 cents to 3 cents per pound, and gives to the manufacturer of crash and the coarser linens an immediate additional protection of 15 per cent. ad valorem. This makes an American flax industry possible. The early establishment

of large linen factories in this country will assure a market for American-grown flax, and the duty of 3 cents per pound on the dressed line, it is thought, will enable the American grower to produce flax fiber with profit to himself.

As flax culture is a new and untried thing with many farmers, the Department will render all aid in its power toward re-establishing the cultural side of the linen industry. Already there is great interest in new machinery and processes for cleaning flax, and some of these give promise of good results.

Hemp culture has been largely extended in States north of the Ohio River, and a perceptible increase in the employment of native hemp in binding twine (in preference to the higher-priced imported sisal and manila hemps) has been noted. Considerable areas of sisal hemp are growing in Florida, and it is thought that with a little encouragement at the outset sisal hemp might readily be produced within our borders. New Zealand flax is growing in California, from which strong fiber has been experimentally produced. Seeds of this plant, and of the manila hemp plant, have recently been imported and distributed for experiment in southern localities.

Several indigenous plants producing bast fiber, growing throughout the South, are under investigation and will be reported upon when the investigations are completed.

In regard to the ramie industry the chief progress of the year has been in the direction of manufacture rather than that of decorticating machinery, though the interest in this fiber continues.

ARTESIAN WELLS INVESTIGATIONS.

By a provision in the urgent deficiency act, approved April 4, 1890, Congress appropriated $20,000, and directed the Department to investigate the proper location for artesian wells and their use in irrigation in the semi-arid region lying between the ninety-seventh degree of west longitude from Greenwich and the eastern foot-hills of the Rocky Mountains. The area includes the States of North and South Dakota, portions of Montana, Wyoming, Colorado, New Mexico, and Texas lying east of the Rockies and the lower Rio Grande River, with those portions of Nebraska, Kansas, Oklahoma, and the Public Land Strip that are west of the ninety-seventh degree. The appropriation was made available the 15th of April, and by the 20th of that month organization was perfected and field work begun by a large and competent staff of division geologists and field agents working under capable chiefs.

The field and official work was heavy, as the law required a report to be made as early as possible after the 1st of July. The supervising engineer and chief geologist made an intelligent though rapid reconnoissance of the whole field, each of them traveling in doing so

about 12,000 miles. The entire field force covered at least 70,000 miles of travel during their work. A report of operations was made on the 22d of August to Congress. The reports of the special agent in charge, of the supervising engineer, the chief geologist, and of the several division geologists and field agents, are accompanied by valuable maps, diagrams, plans, and illustrations drawn from photographs taken for this investigation. Besides the three principal reports, there are four from division geologists, covering the Dakotas, Western Nebraska and Kansas, Eastern Colorado and Southwestern Texas. These contain a mass of valuable data, locating and describing over 1,300 artesian, a large number of bored or gang wells, and several hundred springs, besides presenting important evidence as to the existence of other earth waters in quantities sufficient for economic application to agriculture, when the same can be restored to and distributed over the earth's surface. The reports presented, under the provision of the law of April 4, 1890, are confined directly to the location and availability of artesian waters, all other references and data being incidental. It was found necessary to make for the use of the investigating staff a definition of "artesian water." This was done in the following terms:

To include all subterranean waters, which, on being reached or opened from above, are found to flow to a level higher than the point of contact, and from some permanent and general source rather than from a local and temporary one. All bored wells in which the water rises and all natural waters, such as springs, rising from below, are included in this definition, as artesian in character. These supplies may be divided into positive and negative, the first to include wells the waters whereof flow above the surface of the earth, the second to embrace waters rising with force, but not flowing above.

Taking into consideration the time employed, this series of reports must prove to be of decided economic value. They form a positive contribution to the science of hydrognosy, or the phenomena of earth waters, besides illustrating the possibility of an extensive agricultural utilization of such valuable supplies. A supplementary report relating to earth waters, other than artesian, as defined by this investigation, is now being prepared, under a resolution adopted in June last by the Senate of the United States. This report will deal largely with the evidences of water underlying the river valleys and uplands of the Great Plains region, as under-sheet or underflow, and by percolation, seepage, and drainage.

The brief preliminary reports made to Congress of the artesian wells investigation, resulted in the passage of the following provision of the general deficiency act, approved September 30, 1890:

IRRIGATION INVESTIGATIONS.—To enable the Secretary of Agriculture to continue to completion his investigations for the purpose of determining the extent and availability for irrigation of the underflow and artesian waters within the region between the ninety-seventh degree of longitude and the eastern foot-hills of the Rocky Mountains, and to collect and publish information as to the best methods of cultivating the soil by irrigation, forty thousand dollars: *Provided*, That no part of

said sum shall be expended unless the entire investigation, collection, and publication contemplated herein, including the report thereon, can be fully and finally completed and finished before July first, eighteen hundred and ninety-one, without any additional expense, cost, or charge being incurred.

The extraordinary nature of the above proviso made the formulation of plans for carrying out the investigations enjoined upon me under the act a matter of very serious difficulty. Indeed, a too literal adherence to the language of the act, embarrassed as it is with this provision, would make it well-nigh impossible to undertake the work at all. Assuming, however, after due consideration, that the intention of Congress was that these investigations should be continued, I at once proceeded to organize an irrigation inquiry, and to prepare to carry on the work of artesian and underflow investigation as far along toward completion as was possible by the exercise of the utmost diligence within the period provided. At the same time, I felt called upon to instruct the gentlemen in charge that all reports must be completed and handed in on or before the 30th of April, 1891. The date at which the act was approved, and the early period at which I am obliged to call in the reports, necessarily curtail the time available for field service to a few weeks of field activity, and hence curtail the usefulness of this investigation.

Edwin S. Nettleton has been appointed as chief engineer of this department, and Robert Hay as chief geologist. The engineer at once entered on field work in the Dakotas. He is also preparing plans for the prospective utilization in irrigation of the waters of certain artesian wells. These plans are to be the basis for constructing reservoirs, distributory ditches, etc., the cost of which is to be borne by land owners willing to meet the burden of such experiments.

It has been represented to me that underflow waters can be made available for purposes of irrigation by means of pumping at a less expense than that entailed by the building and maintenance of extensive reservoirs, dams, and ditches. Inasmuch, moreover, as the former plan, should it be found equally effective and economical, would place this matter of supply in the hands of the individual land owner, a feature which is in itself favorable to this plan, I have directed the chief engineer to make a special investigation with a view to supplying reliable information on this point, with such details in regard to the relative cost of the work as will substantiate or controvert the representations in question.

In October Prof. Robert Hay proceeded to Northwestern Nebraska, where, being soon joined by the chief engineer, a series of observations were at once made, both investigations moving southward as rapidly as possible, examining Western Nebraska and Kansas, the adjacent section of Colorado, and the important drainage basins of the Canadian and Pecos Rivers within Eastern New Mexico. Levels

are being run across this mid-section of the Great Plains, and investigation of the underlying strata, their position and relations to the wells, springs, and other evidences of earth waters, are in progress, the results of which I hope to submit to Congress at an early day. It is hoped by these levels and field investigations to quite definitely locate the sources, nature, and extent of the subterranean water supplies. Similar field work will be continued in the Southwest throughout the winter, and at the earliest date that the season will permit active labors will be resumed along the whole line.

The Irrigation Inquiry Office, under the direction of Special Agent R. J. Hinton, is preparing by my orders a concise but comprehensive progress report on irrigation, its development, and the cultivation of the soil thereby. Monographs and reports will also be made through this office by specialists and experts, who will examine and report on such divisions of the arid region as they are most familiar with. This series of papers will include, among others, monographs on irrigation and water supplies in the mid-plains section, Colorado and Wyoming; the basin division, including Northern Arizona, Utah, and Nevada; the Northwest, or Montana and Idaho, with Oregon and Washington east of the Cascade range; also California and Southern Arizona, and the Valley of the Rio Grande.

AGRICULTURAL EXPERIMENT STATIONS AND OFFICE OF EXPERIMENT STATIONS.

The Office of Experiment Stations serves to connect the agricultural experiment stations in the several States and Territories with each other and with this Department, to bring to them the fruits of accumulated experience, to indicate lines of inquiry, to assist them in co-operative effort and in research, to co-ordinate their work, and to collate and publish the results.

During the past year the work of the office has included correspondence; visiting stations; attendance on farmers' meetings, and conventions of college and station officers; the collecting and indexing of station and other literature; the collection of statistics, and the promotion of co-operation among the stations. A most important part of its business has been the preparation of publications, including a record of the current publications of the stations and of this Department; the proceedings of the Convention of the Association of American Agricultural Colleges and Experiment Stations; organization lists of the stations and colleges; circulars and letters of inquiry and information on topics relating to station work; and, finally, Farmers' Bulletins.

The correspondence of the office is large and has doubled in the past year. It relates not only to the scientific, administrative, and general interests of the stations, but also to numerous and varied

problems in agricultural science and practice, and extends to all parts of the world.

The increase in the amount and improvement in the quality of the work of the stations and the establishment of new ones have caused corresponding increase in their publications. The editorial work of the office is consequently enlarged, and the Experiment Station Record for 1890–'91 will include twelve numbers instead of six, as in the previous volume. The Record, with its index, makes it easy to ascertain what the stations are doing in any given line of investigation, what are the main results, and where the published details are to be found. It will thus be increasingly valuable. Further provision for collating and disseminating information is made in the Digest of Station Reports and other technical publications of the office.

Each station distributes its own publications freely in its own State, but can send very few outside, although the results reported would often be equally useful in other States. To provide for the general distribution of such information to the farmers of the whole country a series of inexpensive popular bulletins has been planned. Of the first of these an edition of 50,000 was speedily exhausted, and its statements were widely quoted by the agricultural press. A second bulletin illustrated the results of inquiries pertaining to topics of practical interest. An edition of 150,000 was issued, of which 75,000 were distributed through members of Congress. The nature of these publications led to the name "Farmers' Bulletins." The work and connections of the office are such as to bring to its attention a great amount of information of the highest value to the farmer, and I earnestly hope that the printing fund of the Department may be so enlarged as to enable these popular publications to appear more frequently and in larger numbers than heretofore.

One direction in which the sphere of the office should be enlarged is the collating of the fruits of agricultural inquiry in Europe, where during the past forty years numerous experiment stations and kindred institutions have been studying the laws that underlie the right practice of farming, with results that are constantly increasing in volume and value. Our station workers need this information to enable them to avoid going over old ground and making old mistakes and to suggest to them the most advantageous methods and lines of research. The Department needs it for its own investigations and to enable it to give to the stations the advice and assistance which they desire. So urgent is the need that this work must be undertaken at once, but that in order that it may be carried on effectively and with sufficient thoroughness, an addition to the appropriation for the office is imperatively demanded. Well done, this work would save years of experimental investigations in this country; without it the loss of labor, of money, and of needed information will be great.

Plans have been suggested and are under consideration for coöp-

erative investigations on the soils of the country; fertilizers; sugar-beet culture; dairying; foods and feeding stuffs; the improvement of native grasses, forage plants, and wild fruits, and the introduction and acclimatization of new economic plants, the successful culture of which will substitute home-grown for foreign products. For the most advantageous carrying out of these plans there is need of more frequent visiting of the stations by the representatives of this Department, especially of this branch of it, and of the occasional calling to Washington of the directors and leading workers of the stations for consultation.

A review of the work and condition of the experiment station enterprise in the United States is on the whole decidedly encouraging. During the past year eight new stations have been established, viz., in North and Southeast Alabama, Arizona, South California, New Mexico, North Dakota, Utah, and Washington. Experiment stations are now in operation under the act of Congress approved March 2, 1887, in all the States and Territories except Montana, Washington, Idaho, Wyoming, and Oklahoma. In several States the United States grant is divided, so that 52 stations in 43 States and Territories are receiving money from the United States Treasury. In several States branch or substations have been established. If these be included the number of stations is 70.

These stations with this office expend in all about $785,000 per annum, of which $660,000 is appropriated from the National Treasury. They employ over four hundred persons in the work of inquiry, and are conducting a large amount of research in the laboratory and greenhouse, and of practical experimenting in the field, the orchard, the stable, and the dairy. During the past year the stations have published about 300 reports and bulletins, aggregating about 10,000 printed pages. At a low estimate 3,000 copies of each of these publications have been distributed, making a total of 30,000,000 pages, containing information on agricultural topics, directly disseminated among the people by the stations during one year, and thousands of newspapers and other periodicals have quoted from these publications the results, and to some extent the processes of the experiments described. It is believed that no means for popularizing the teachings of scientific research has yet been devised which in scope and far-reaching effectiveness surpasses this for the diffusion of agricultural science.

A marked feature of the enterprise is the close relation already established between the stations and the farmers. In many of the States members of the station staffs have been either organizers of farmers' institutes or among the foremost workers in them. The calls upon the station officers for public addresses are numerous and increasing. The station correspondence with farmers is very large, and touches almost every topic connected with farm theory and prac-

tice. Moreover, the results worked out by the stations are applied and enlarged by farmers who conduct trials upon their own farms on plans indicated by the stations, and the proof thus brought of the capacity of our intelligent farmers for experimenting is most gratifying. In short, the station and the farmer are working together and to the advantage of all concerned.

Another encouraging fact is the aid given the stations by State legislatures, local communities, agricultural associations, and private individuals. From these sources the stations have received during the past year about $125,000 in money, in addition to other gifts of land, buildings, and equipment. This indicates that the generous policy pursued by the General Government is acting already in the case of the stations, as it has done for a longer time in that of the land-grant colleges, as a proper stimulus to generosity on the part of the States, communities, and individuals, and that on the foundations laid by the General Government are to be built large and strong institutions.

The union with the agricultural colleges by which the stations have secured the advantages arising from the use of libraries and laboratories, and from connection with specialists, teachers, and students; the influences exerted by the Association of American Agricultural Colleges and Experiment Stations, and, finally, the earnestness and enthusiasm of the station workers, all conspire to give the promise of constantly increasing usefulness.

DIVISION OF RECORDS AND EDITING.

While this division, like several others, was actually called into existence last July, when the act of appropriation which included a provision therefor became a law, the work was practically done under another division in such a manner as to necessitate no reorganization of the work when it became an independent division. For convenience it will therefore be referred to in this report as a division, even with regard to the work done before it was properly raised to that dignity.

Since my last report this division has transmitted to the Public Printer the manuscript for eighty bulletins, besides supervising the printing of the Annual Report of the Department. With reference to the majority of these bulletins it has also prepared the usual synopses on the plan indicated in my last report, whereby as was anticipated the circulation of the bulletins has not only been greatly increased, but it has been effected far more promptly than was usual heretofore. The advantage of prompt distribution is especially appreciable in regard to the bulletins of this Department, relating as they do to the practical work of agriculture, which itself depends upon times and seasons with such regularity that delay in the distribution of a bulletin of a few weeks or even a few days in some cases

may render it unavailable to the farmer for practical use until another season. An effort has been made to exercise greater discrimination in the distribution of bulletins, by which those relating to particular branches of agriculture should reach only those engaged therein. A great waste of bulletins has thus been avoided, and the circle of those who are benefited by the Department bulletins has been enlarged in far greater proportion than the number of copies distributed.

The work of publication of the Department has been much aided by the establishment of the division. Indeed, this work has attained such proportions that it is eminently desirable that there should be one office serving as the channel of all communications between this Department and the Public Printer, and the result has, I believe, been as satisfactory to that official as to ourselves. It is only just that I should here give due credit to the efficient management of the present incumbent of that office for results which have given us during the last twelve months, at an expense slightly less than that of the twelve months previous, publications aggregating in number of copies 1,133,000, as against 566,000 for the twelve months previous. At the same time a due share of the credit for the excellent results and good administration of our printing fund during the past twelve months belongs to the new division. In spite, however, of these advantages, I regret deeply to have to report that for want of a sufficient printing fund useful publications have had to be unduly postponed, while some have had to be abandoned altogether. The amount at the disposal of the Department for the previous fiscal year was $39,235.45, a sum even less than that of the year preceding, which was $40,914.37, and both these years this amount was secured only by obtaining a deficiency appropriation. Notwithstanding the immense increase in the number of divisions over two years ago and the fact that the accumulated experience and efficiency of divisions long established increase the number of publications, the appropriation for the current year is only $40,000, a sum less than that expended two years ago.

The measure of the efficiency of the Department of Agriculture is largely its ability to supply practical, useful information to the public, and I can not but deplore in the strongest manner any policy which shall weaken the power of the Department for good in this its most useful field of labor, because that which is essential to the practical results of every other. To concentrate the time and ability of the chiefs of the several divisions and their assistants upon the investigation of problems with which our farmers have to contend, and when practical results have been obtained to withhold the means of making them public for the benefit of those whom the Department is created to serve, seems to reach the heights of unwisdom.

With regard to the publication work of the future, I have found that it will be necessary to divide the publications of the Department

into three classes. The scientific work of the several divisions, for obvious reasons, must be recorded in a form available to the scientist and to the student. Even where no practical results are immediately obtained, the work done is so much accomplished on the way toward them, and the preservation of a record thereof for future reference will save to us needless repetition. Limited editions, therefore, of a series intended to serve as a technical record of the scientific work of the several divisions are needed. A second series, in the form of special bulletins containing the results of investigations and information of value to specialists in agriculture, to be issued in editions considerably larger, must be undertaken for the benefit of those who, without being scientific in any sense of the word, are engaged in some practical department of agricultural work, such as horticulture, dairying, stock raising, etc. In addition to these two series, we have found it desirable to cause the publication from time to time of short practical tracts, inexpensive in form, devoted to some special feature of agricultural work calling for clear, concise instructions, within the comprehension of any person able to read them, and available for immediate distribution in some particular section or to some particular class. The circulation of these bulletins must vary according to the demands of the occasion.

Again, as in the case of this class of bulletins issued through the Office of Experiment Stations, Farmers' Bulletins 1 and 2, it is desired to give in the plainest possible manner the gist of experimental research throughout the country on some one or other of the many important agricultural problems which it is the province of the stations to investigate and solve. To fully cover the field of publication to the extent which I deem absolutely essential to this Department, I have been obliged to name the sum of $60,000 as the minimum amount necessary to carry out my purpose. In this connection I will only add that it is not only unsatisfactory, but seriously prejudicial to the efficiency of the work, to be compelled year after year to formulate plans of publication on an insufficient appropriation, trusting to a deficiency appropriation to supplement it. Many of our publications need six months' careful preparation, and, as I have already pointed out, delay in publication when a bulletin is ready often means a loss of one year's time to the farmers of the country.

DIVISION OF ILLUSTRATIONS.

Considerations in some degree analogous to those which led me to establish a division of records and editing led to my organizing the work of illustrations as a separate division, which, under the competent direction of a single chief, should include all the draughtsmen and engravers employed in the Department. These have been heretofore scattered here and there among the several divisions, and I

concluded that better results would follow from the performance of all the work of this character under the direct supervision of a competent artist. Moreover, I am well satisfied that a considerable saving will be effected in the expensive work of illustration by the existence of an officer charged with responsibility for supervising this branch of the work for all the divisions of the Department, thus affording to the chiefs of the several divisions an associate whom they should consult in reference to all contemplated work of this character. The work of this division has been, as it were, but just begun under the new order of things, even sufficient room having been lacking at the time the division was created; and this room has only just been provided, although I regret to say the accommodations, for reasons which I have sufficiently amplified when dealing with the question of the buildings, are far from adequate for the work required of it.

SEED DIVISION.

The distribution of seeds for the year ending June 30, 1890, exceeded in number of packages that of any in former years, although the appropriation for that purpose was the same as that granted in years immediately preceding. This was due to a radical change made in the method of purchasing seeds, and to which allusion was made in my last report, namely, the employment of a special agent, whose sole duty it is to visit personally different sections of the country and inspect, as far as possible, the product of the seeds offered to the Department and to look up such as seem to possess especially desirable characteristics. The result has been so satisfactory that, with an expenditure of money for the purchase of seeds no greater than that of the previous year, the number of packages of seed distributed has exceeded that of the previous year by three quarters of a million, the fact being that the total amount of seed distributed by this Department during the last fiscal year would, at the prices paid during the previous year, have cost the Department $18,000 more than it has. An earnest effort has been made to introduce new and important varieties of seeds, many having been secured for that purpose in foreign countries. I may refer especially in this connection to the Ladoga wheat, Bermuda grass seed and the sugar-beet seed.

I have also continued and enlarged the distribution of seed to State experiment stations, these institutions having obviously the best facilities for giving the seeds a thorough trial and for making such reports regarding the same to the Department as will enable us to arrive at just conclusions as to the adaptability of the seeds to our climate and soil, as to the best methods of cultivation, etc., thus enabling us to accompany further distribution, if such be decided upon, with intelligent and reliable instructions.

DIVISION OF GARDENS AND GROUNDS.

This division is charged with the care of the grounds and conservatories surrounding and attached to the Department buildings. The grounds include some 40 acres, with roadways, walks, trees, etc., to be looked after and kept in order; and in the conservatories and propagating houses are conducted the propagation and culture of economic plants. The distribution of these plants throughout the country, with due regard of course to the climatic conditions favorable to their growth, devolves upon the Superintendent.

The conservatory attached to the Department is a common resort of visitors to the national capital, and I have been impressed with the fact that its educational features have not been as complete as it seems to me is desirable. These conservatories are not only among the finest in the country, but the plants they contain having been selected according to a special design and embracing a very large variety not only of the ornamental, but especially of the economically useful varieties, much useful instruction would result to visitors by the preparation for free distribution of a carefully prepared catalogue, provided with reference numbers and a plan of the greenhouses, so that the several plants could be readily identified. As so large a portion of the conservatories is devoted to plants of economic value, this catalogue should be sufficiently full to explain the value of each plant, as well as the method of cultivation and of the preparation of the commercial product. I have accordingly made arrangements for the preparation of such a catalogue, and am quite satisfied that when completed the work will not only reflect credit upon the Superintendent of Gardens and Grounds, to whom it is intrusted, but will be found of great interest and value to visitors to the conservatories; indeed, it will no doubt have the effect of greatly increasing the number of visitors, especially of those whom it should be the object of all public institutions to serve in a particular manner. I refer to young people in attendance upon our educational institutions.

The plants distributed through this division during the past fiscal year amounted to over 80,000, and included olives, tea, coffee, camphor, strawberries, grapes, both native and foreign, citrus of many species, raspberries, date palms, figs, Japan persimmons, currants, loquats, guavas, pine-apples, black pepper, vanilla, mangoes, and bananas. Reports as to the results obtained with the plants so distributed are encouraging. The culture of the olive is fairly established on the Pacific coast, and it seems likely that it can be profitably established on the Atlantic coast as well, the tree being well adapted to the climates over a wide range in the Southern States. With this end in view, the Department recently imported some of the best selected varieties, which are now being propagated for

eventual distribution in suitable localities. There were also distributed some 10,000 cuttings of Smyrna figs of carefully selected varieties, such as furnish the dried figs of commerce.

At present the camphor tree is found well adapted as a shade tree in Florida, where suitable shade trees are a matter of special interest, and many plants have been sent into that State during the past ten years. It is hoped that at some time the plant may be profitably utilized for its commercial products. With the increased demand for camphor, it is believed that the prices for the article would warrant an extension of the plant in some of the Southern States. It has been proved to withstand the climate of the Atlantic coast as far north as Charleston, S. C. It is a hardier tree than the orange, probably nearly as hardy as the olive. To enable those who may desire to experiment with the tree, a quantity of plants will be propagated sufficient for a generous distribution in the near future.

The black pepper, vanilla, cinchona, and the cocoa (*Erythroxylon coca*) are being propagated and have been distributed to some extent. Their success is as yet somewhat problematical, but is possible in some situations in southern Florida, where these plants may obtain permanent foothold.

The importance of this work in the general encouragement of the growth of useful and economic plants is shown by the large amount of imports of fruits, nuts, spices, and vegetable products, which could certainly be much reduced were the cultivation of these plants undertaken, if only in those limited localities where they can be cultivated with assurance of success.

THE WEATHER BUREAU.

Under an act approved October 1, 1890, Congress directed "that the civilian duties now performed by the Signal Corps of the Army shall hereafter devolve upon a bureau to be known as the Weather Bureau, which, on and after July 1, 1891, shall be established in and attached to the Department of Agriculture."

In accordance with this act I have included estimates for the ensuing fiscal year for carrying on the work of the bureau thus created in this Department. I deem it evident from the discussion which attended the passage of this act, and from the wording of the act itself, that in making this transfer of the Weather Bureau to this Department it was the intention of Congress that the work of the bureau should be extended, in so far as might be necessary to a full co-operation of this branch of the service with the work of the several divisions already established in this Department for the benefit of agriculture, without in any way restricting its general scope. In this spirit I have submitted estimates for the coming year on the basis of the wider range of work thus contemplated, and I take the

opportunity of expressing here my own conviction that in many ways the work of meteorological observation which this Department will be thus enabled to carry on in conjunction with its other work, will be found of great value to the farming interests of the country. It is indeed self-evident that to complete the study of soil conditions, of animal and plant life, a study of the climatic conditions of our country is indispensable.

REPRESENTATION OF THE DEPARTMENT AT FAIRS, ETC.

In my last report I referred to the fact that there are held in this country annually a vast number of fairs—usually a State or Territorial fair in every State and Territory in the Union, many other large district or interstate fairs, while county fairs are very nearly as numerous as the number of counties in the whole country. It is a very essential part of the duty of this Department to keep itself well informed in regard to the extent and character of the agricultural resources of all sections of the country, and I know of no opportunity for adding materially to this information at so slight an expense of time and money as is afforded by these exhibitions, which bring together in one place samples of all the best that the country can produce.

It is my desire that the representatives of this Department should be found hereafter at all the principal State fairs, under instructions to make a thorough report on the character of the exhibits, and at the same time to avail themselves of meeting, as they will do on such occasions, the leading representatives of agricultural interests, from whom much can be learned as to the wants of the farmers, the nature of their difficulties, and the best manner in which the Department can serve them. Furthermore, I desire to carry this system of representation at the fairs as far as possible, even to include county fairs, by availing myself of the co-operation of the large staff of voluntary correspondents of the Department distributed through all sections of the country, and to whose enthusiastic devotion to the cause of agriculture the Department has already been often and much indebted. It seems to me that by such means a sort of bird's-eye view, as it were, might be obtained of the agricultural resources of the country, with the result of supplying this Department with a vast amount of valuable information which can not only not be secured so easily in any other way, but indeed can not be secured at all except by these means.

Among other services which these representatives could render the Department would be the collection and forwarding to the Department museum samples of the various exhibits which at present are too frequently scattered and lost. This subject naturally leads to a consideration of the necessity for a more frequent inter-

change of thought between this Department and the agricultural intelligence of the country. I called attention in my last report to the fact that there had been, especially in the past few years in the United States, an enormous development in the agricultural organizations devoted to the farmer's self-improvement. Our dairy associations, our horticultural, life-stock, and kindred societies, have not only multiplied as to number, but to-day are far more active in holding meetings and conventions than they have ever been before. The farmers' institutes are meetings of a general character, attended usually by the best farmers in the sections in which they are held, and bringing together the best agricultural thought and practice. Not only do I deem it to be of the utmost importance, indeed a solemn duty devolving upon this Department, that these meetings and gatherings should be encouraged in every possible way by their representative Department in the National Government, but I conceive it to be absolutely necessary for the intelligent conduct of the work of this Department that it should be frequently represented at such meetings, not only for the encouragement and benefit of those present, but for the benefit of this Department and its division chiefs.

Speaking from my own experience, I am aware that in the large section of country with which I am familiar, from an agricultural standpoint, most important meetings have been held in recent years. Questions of the gravest import to the agriculture of this country have been discussed at these meetings, and yet rarely indeed has there been present any person representing the National Department of Agriculture who could speak for it, and what is still more important, learn for it the views and wants of these people. This is a condition of affairs which calls for immediate remedy, and in so far as the liberality of Congress will enable me to do so, I am determined to provide that remedy. It is only by the closest co-operation between this Department and the agricultural societies—the Granges, the Alliances, etc.,—that the work of the Department can be carried to its highest development and attain its greatest usefulness, and I recommend that a special fund be placed at my disposal for this purpose.

COLUMBIAN WORLD'S FAIR.

The act of Congress approved April 25, 1890, gave national assent to and recognition of the proposition to hold a World's Columbian Exposition in the city of Chicago in the year 1893. The bill provides that there shall be prepared a governmental exhibit. For the purpose of securing harmony of installation and arrangement, it was provided that a board consisting of persons to be designated, one each by the head of each Department, should be formed. In compliance with this law I designated the Hon. Edwin Willits, Assistant

Secretary of Agriculture, as representative of this Department upon the board, and you ratified this nomination and designated him as its chairman. Mr. Willits informs me that doubt upon the part of the accounting officers of the Treasury has already been expressed as to the availability of the funds appropriated by Congress for the work in hand, and at this writing we have an intimation that nothing can be purchased, nothing constructed, nothing exhibited which is not now in the Departments, and that no outside assistance can be employed in any branch of the work of preparation.

In so far as the Agricultural Department is concerned, I say without reservation, it were better to abandon the attempt to make any exhibit than to undertake the task with such limitations. It certainly is not my intention to enter the exposition field in competition with the private, State, or corporate exhibitor, but beyond this field there lies a wide region wherein this Department may operate in illustrating those functions which are peculiarly its own. This Department is instinct with science. A process can not be fully illustrated on a printed page, and this exposition furnishes a rare opportunity, which hardly comes twice in a lifetime, to supplement the publications, at present its only means of communicating with the public, by a spectacular exhibition of current methods of dealing with agricultural problems and processes. If the work devolving upon this Department in connection with this exposition is to be undertaken at all, it must be in such a manner as to guaranty satisfactory results; and in its performance we must be left at liberty to avail ourselves of such material and such expert assistance as we can find adapted to the purpose. I commend the subject to your attention in the hope that any obstacles to effective work now existing may be removed by Congress, and that the work may proceed without delay.

THE MUSEUM.

The needs of the Museum have continued to receive my most thoughtful attention. A marked improvement in the appearance of the exhibit has been effected by its re-arrangement and renovation; and plans have been perfected by which, it is believed, the aid recently granted by Congress will be applied to the best possible advantage. The educational, scientific, and historical interests which would be promoted by a distinctly agricultural museum of suitable character are too generally recognized to need urging at this time. It should be a matter of regret, however, that for the thousands who annually visit us from abroad, impressed in advance with the magnitude and diversity of our agricultural productions, we should have no permanent national collection fitly illustrating the products of our soil. The need of such a collection, moreover, is being keenly felt in investigations prosecuted by this Department,

and involving important economic questions, the solution of which could be materially facilitated and hastened by access to the actual results of cereal growth attained under various conditions of soil, climate, and culture. I deem it a fitting time to suggest that proper foresight on the part of Congress should secure for this Department, after their exhibition at the Columbian Exposition, such available articles relating to the operations of agriculture as shall be worthy of place in a permanent exhibit; and that in the meantime suitable provision be made for the accommodation of the present collection and subsequent accessions.

ADEQUATE BUILDING FACILITIES.

A consideration of the wants of the Museum brings me to the question of adequate building facilities. The want of these is conspicuously illustrated by the unavoidable utilization of a huge, unsightly wooden structure, far inferior to many an exhibition building on a country fair ground, as an agricultural museum; furthermore, the building being made to do service on occasion as a general storage warehouse, and to accommodate not only the silk filature and cocooneries, but a number of offices for which I need hardly say it is most illy adapted. Moreover, its use for this purpose necessitates dividing the force of several divisions, one part of the force being at work in one building and another part in another, a condition of things which is found a serious impediment in carrying on the work. All the more important divisions are suffering grave inconvenience, and important work is unavoidably delayed owing to this condition of things; in fact, a vast amount of time and pains, which might have been profitably devoted to more important work, has to be unavoidably spent in devising ways and means to overcome, or at least to mitigate, the embarrassment and annoyances, amounting to serious obstruction to the work of the Department, entailed by this want of room.

I must therefore renew in the most energetic manner my earnest recommendation that immediate steps be taken to provide this Department with an additional building, suitable for the accommodation of all the laboratory work of the Department, and at the same time of a number of the offices, as well as with fireproof accommodations for the reception of the valuable herbarium and other property of the Department, which it has cost years of labor and large sums of money to accumulate, and which, if they should ever be destroyed, no amount of time and no amount of money could possibly replace.

PROMOTION OF CORN CONSUMPTION IN EUROPE.

I have long been impressed with the necessity of taking measures to promote the consumption of Indian corn in foreign countries. The facility with which we can raise this cereal, its generally low price,

and the occasional glut in the home market in years when the yield has been especially large, make an increase in our exports of corn extremely desirable. It is essentially an American cereal, one which can be grown in all parts of this great country, and the area adapted to which is practically illimitable. Not more than 20 per cent. of the crop on an average is moved outside of the county in which it is grown, and to the extent to which this indicates the utilization of the crop for feeding purposes on the farms where it is grown this is well; but when we realize that this fact is due in part at least, especially in years, like the last, of an ample yield, to the absolute want of demand, our home markets being fully supplied, it is certainly a matter of profound regret that there does not exist a foreign demand sufficient to relieve the glut at home, and to secure for our farmers in the West a price which would be adequate at least to save them from loss on the growing of the crop.

During the past ten years our exports have hardly exceeded 3 or 4 per cent. of the total crop. This is due largely to the fact that corn is utilized throughout the greater portion of Europe solely as food for animals, and then only when its very low price tempts the feeders. As a food for human beings it is practically unknown, save in some sections of Southern Europe, while in the greater part of that continent it can not even be grown to maturity. I have recently determined to avail myself of the presence in Europe of Col. Charles J. Murphy, a well-known authority and enthusiast on the subject of the increase of our corn export, who has been commissioned by me to make a report to this Department upon the general subject of the promotion of the use of Indian corn as a human food in European countries. Colonel Murphy's report will be made the subject of a special bulletin as soon as it shall have been received, and will no doubt treat of this important subject practically and well.

REPRESENTATION OF THE DEPARTMENT ABROAD.

I desire to record here very emphatically my conviction that some method must be adopted by which, as occasion requires and without long delays, this Department shall be enabled to send representatives to foreign countries in cases where only personal visits can be relied on to secure much-needed information. The subject of world-wide competition has been dwelt upon at length on so many occasions that it would be purely superfluous to insist here upon the active competition which meets our own farmers in every market where their products are offered for sale. The commercial side of this condition of things is well understood, but it does not seem to be so clearly understood or so well appreciated that there is an intellectual competition which is even more serious than the other, in that it is the basis of the other.

Where wise economic legislation is the cure, the perfection of agricultural methods, which means the maximum of production at the minimum of cost, is the prevention of agricultural troubles. In our pursuit after this perfection we must study the methods of all other countries that attain or approach it in any branch of agriculture. We must be prepared to learn all that is to be learned elsewhere, and then wisely adapt the information so obtained to the conditions of the American farmer. Consequently that information must be acquired by men who are themselves familiar with our own agricultural conditions. This plan, except in so far as it is now offered on behalf of agriculture, is by no means a new or original one. It is but a few years since that a commission of distinguished military officers visited many of the European countries and British India for the purpose of studying the equipment of foreign armies with a view of adapting to our own military service all that might seem to be advantageous. I have understood that the report brought back by these gentlemen was regarded by high authorities as most valuable. In this respect, as in many others, agriculture has not had the fair treatment which, in spite of the fact that it is beyond dispute the most important industry in the country, is, after all, all that it asks for. The suggestion of sending a well-qualified representative abroad purely in the interest of agriculture is cavilled at as a means of affording a pleasure trip to some broken-down professor. It is time that we rose superior to such humiliating and unworthy puerility.

It may be well, perhaps, in this connection to call attention to the fact that we are in this respect far behind the other nations of the world, however disagreeable it may be to confess it. Important gatherings of men devoted to agricultural science, and enjoying by the courtesy of the government under whose jurisdiction they assemble every privilege and facility for gaining information in regard to the agriculture of that country, are constantly being held in various parts of the world, at which representatives of this, the greatest agricultural country in the world, are conspicuous by their absence, and when we are represented it is often by some wealthy amateur enjoying his ease abroad, or, as is sometimes the case, by some enthusiast, who, at a sacrifice of time and money which he can ill afford to spare, manages to attend; but officially this country and this Department are very rarely represented on such occasions. A most notable instance of our omissions in this respect was furnished during the meeting last September of an international agricultural congress at Vienna, in which we had been especially invited to participate by the Austro-Hungarian Government, at which over eleven hundred delegates were present, including distinguished representatives of agricultural interests from every country in Europe, from Japan, from Australia, from India, and from South America, and at which were discussed subjects of profound interest

to American agriculture. This was a meeting at which, for many reasons, it was most desirable that the United States, through this Department, should have been officially represented. Unfortunately, for want of adequate provision, the United States alone, of all the leading countries of the world, was absent.

Let me here recall the fact that since I had the honor to assume the office of Secretary of Agriculture I have been visited by gentlemen from Austro-Hungary, Germany, Bavaria, France, Great Britain, Canada, Australia, New Zealand, Japan, and even from one of the native principalities of the East Indies, the official representatives of departments analogous to my own in their native countries, traveling under orders from and under the pay of their respective governments, armed with all the official credentials necessary to secure to them every attention and courtesy necessary to the prosecution of their inquiries. Thus do these countries indicate their willingness to learn whatever we may be able to teach them. Thus do they recognize the fact upon which I have already insisted—that there is an intellectual as well as a commercial competition, to which the old maxim, "Knowledge is power," applies with a force which all must recognize.

In concluding this my second annual report as Secretary of Agriculture, I feel amply justified in expressing my general satisfaction at the condition of agricultural matters in our country. It is true that in many cases the effects of former agricultural depression are still felt, and it is also true that in a vast country like ours there must be at all times more or less depression existing in one section or another and affecting some local interests. Nevertheless, a careful review of the events of the past year and a general survey of the agricultural field to-day betoken marked improvement in the condition of our agriculturists and promise well for their future well-being.

The recognition of agricultural interests in recent national legislation will have the double effect of assuring the farmers of the appreciation of their wants as a class by our public men and of securing to them many beneficial results in the near future. I have also had frequent opportunities of noting with sincere gratification the rapidly growing tendency of our farmers to avail themselves of the work of this Department in its many branches and their constant thirst for more information, not only in regard to the statistics of agriculture, but as to the scientific principles which all are now beginning to recognize as lying at the very foundation of successful agricultural work. That the means for imparting this information exist in this country through the liberality of the National Government on a scale far beyond any that has been attempted in any other country under the sun, is a fact which all must gratefully

acknowledge, while this very fact, coupled with the earnest demands for increasing information, it must not be forgotten, adds largely to the burden of responsibility imposed upon this Department and its officers, upon the national legislature, which is responsible for providing it with the means necessary to enable it to satisfy these constantly increasing demands for information and advice, and upon those numerous institutions scattered throughout the country and specially endowed from the National Treasury to labor for the benefit of agriculture.

Much indeed has been done for agriculture in this country. Much more remains yet to be done; but relying upon the results of an earnest co-operation on the part of all the great forces which I have indicated as at work in this behalf, and confident of the cordial support of the people of the United States in all steps taken by the National Government to further the interests of that great foundation industry of agriculture, upon which the future prosperity of the country so essentially depends, I look forward with courage to the work that lies before us in the future and with confidence to the time when, in the high quality of its work as well as in the magnitude of its enterprises, the agriculture of the United States shall not only lead all other industries in this country, but shall be the leader in this great industry of all other countries.

In the hope that together with the people of the United States you may be led to the same encouraging conviction by a consideration of this report, I have the honor to respectfully submit the same.

Very respectfully, your obedient servant,

J. M. RUSK

Secretary.

SPECIAL REPORT OF THE ASSISTANT SECRETARY

SIR: In accordance with your request, I beg leave to submit the following review of the scientific work of the Department in its relations to practical agriculture, to form a part of the Annual Report of the Department.

Trusting that it may fully cover the object which you had in view, and that its publication may serve to emphasize in the minds of the readers the determined effort in every division of this Department under your administration to conduct all the work in a manner subservient to the best interests of practical agriculture, I have the honor to remain,

Very respectfully, yours,

EDWIN WILLITS,
Assistant Secretary.

Hon. J. M. RUSK,
Secretary of Agriculture.

THE SCIENTIFIC WORK OF THE DEPARTMENT IN ITS RELATIONS TO PRACTICAL AGRICULTURE

Agriculture to be permanently successful must be founded on, and conducted according to scientific principle. As all legislation not in accordance with fundamental economic laws will sooner or later fail in its beneficent purpose, so agriculture without an intelligent apprehension of its conditions and limitations, without a wise consideration of the laws to which it is subject, without a proper application of every means to enhance its productiveness, will ultimately fail to respond to expectations and will bring disaster to the farmer. Nature can not be cheated, and her implacable laws will surely find out their transgressors. There is a plague-stricken soil as well as a plague-stricken population. Sanitation and vegetation are not accidents: for both there are arts that promote and arts that prevent injury. Science is at the bottom of each.

Science is classified knowledge. This knowledge comes from experience and from investigation. It is as important to know what

has been done as to know what it is possible to do. Science arranges the facts of the former in line and finds a law; or it investigates, projects itself into the unknown, and discovers other laws or amplifies those already known. Men who heed these laws avoid mistakes, conserve their energies, and double production.

The practical farmer too often forgets or ignores what he owes to science. He perhaps is sometimes not aware of the obligation. How many farmers, for instance in the temperate zone, would be moved to build a monument to the man or men who invented hay as adapted to modern use? Yet in a large sense hay is a modern discovery, based upon long experiments made in the importation, cultivation, and improvement of grasses till then unknown to the agriculturist. As recently as the sixteenth century the average weight of the bullocks bought for the English navy was less than 400 pounds. For want of hay the sheep were mostly killed in November, and such as were left were, with the oxen, starved through the winter, so that improvement was impossible. The grass experiments, scientific and practical, of the Duke of Bedford and others, made the 2,000 pound bullock possible, by furnishing food for continuous unstinted growth, winter and summer, from birth to maturity. It was by no accident that the few useful grasses upon which are based the live stock and dairy interests in the magnificent proportions of the present time were brought from diverse countries and made subservient to the interests of mankind.

How long it took the world to learn that proper rotation of crops "rests the land" as effectually as fallowing, thereby saving one crop and sometimes two a year; to learn that the increase of live stock on the farm within and under certain conditions increases its fertility; to learn that artificial drainage warms and lightens cold and heavy soils, advancing the harvest by weeks and bringing the subsoil to the relief of the impoverished surface, by which as some one has said we find a new farm under the old one, or as Emerson so graphically says, "by drainage we have gone to the subsoil, and we have a Concord under Concord, a Middlesex under Middlesex, and a basement story of Massachusetts more valuable than the superstructure." These matters were all demonstrated by the application of scientific principles long before adoption by the world at large.

It is perhaps a waste of words to continue a further discussion of what agriculture owes to science. Illustrations multiply as the ever-widening field is traversed. Suffice it to say that to the introduction of scientific methods and processes is due in large measure the elevation of those who till the soil to their present high estate. Science carries intelligence with it wherever it goes, and its wains are freighted with the burdens of increased harvests. In line with this sentiment and in furtherance of the demand of the farmers of the United States, was founded

THE DEPARTMENT OF AGRICULTURE.

As far back as 1822 a strong effort was made to transform the "Mall," some 200 acres, between the Capitol and Executive Mansion, then almost a barren waste, into an experiment farm, in which should be propagated for distribution new and rare seeds and plants. Nothing came of the agitation in that form, but in due time a division was established in the Patent Office to gather facts and disseminate information for the benefit of agriculture, and after a while to purchase new and rare seeds and plants in limited quantities for gratuitous distribution. The demand for better things grew till finally a separate and independent department was set up on 40 acres of the "Mall" which forty and more years before was sought for an experiment farm. With this transfer came enlarged powers and duties. In accord with enlightened progress, the means were given for original, scientific investigation. Several new divisions were created for that purpose, among which chemistry was chief. Since then, from time to time, other lines of inquiry have been added till there is hardly a topic of investigation relating to agriculture, suggested by modern thought, that is not in greater or less degree covered by the work of the Department. Its halls are instinct with science. The chiefs of the divisions and many of their subordinates are eminent in their special lines, and are recognized for their work and their ability the world over as the peers of any like body of investigators, seek where you may.

One of the gratifying features of this development in scientific research is that the practical character of the work has not one whit abated. Much more than one half of the money appropriated is used for the gathering of facts and statistics, for the purchase and distribution of seeds and plants, for the extirpation of contagious diseases of animals, for the introduction of and experiments with forage plants, for the inspection of meats and animals intended for export, and finally, for the dissemination of information. The most abstruse scientific inquiry is tempered by a practical impulse. The best scientific work has for its end the useful and the permanent good of agriculture. Here is exemplified what history again and again shows, that the best and highest scientific work has always been allied with the useful. Men need to be harnessed to facts, theories need to be in touch with realities to produce the best results; truths substantially verified in our experience. At the same time the publications issued by the Department constitute a mass of information the most extensive and varied among the nations of the earth. The annual report, of 400,000 copies, constitutes the largest single edition of any book published. In their practical character, in their scientific worth, and in the promptness of their issue, our publications are the admiration of all representatives of foreign

governments accredited to the Department to study its workings and efficiency.

So much it is thought is due to make it clear that in this development the cardinal purpose and duty of the Department is not lost sight of. It remains now to consider in detail the

SCIENTIFIC WORK OF THE DEPARTMENT.

This work may be properly divided into three classes: (1) The experimental; (2) the remedial; and (3) general science.

As a matter of fact this classification is not made by divisions, but largely characterizes the work of all the divisions. The classification is generic, not divisional.

I.—THE EXPERIMENTAL.

This may be subdivided for more clear definition into (1) the empirical, and (2) the economic.

The empirical.—This term empirical is used for the want of a better, though not strictly accurate. By the term is meant that class of experiments which are not popularly considered scientific, though in fact based upon a scientific principle. This work is more fully carried on by the Seed Division, the Horticultural Division, the Pomological Division, and the Botanical Division.

The distribution of improved and valuable seeds and plants is sound policy, because based upon natural law. In a wide sense nature has made her own distribution which all experiments must recognize, and it is the study of the laws of this distribution that constitutes the scientific element of the empirical work, and which renders our definition not strictly accurate. For instance, it was practically a useless waste of funds to distribute cotton seed to the State of Michigan, which was done for a while under the ironclad appropriation that each Congressman should receive his quota of all seeds—an anomaly subsequently rectified. Climatic and other considerations (really scientific) should have their weight in the purchase and distribution. But, within comparatively certain lines, there is a wide field for improvement in quality and product, by the judicious introduction of new varieties and the transfer of valuable ones from one locality and condition to another.

While nature in the broad sense has placed her varieties of vegetable life in the regions to which they are best, and sometimes where they are exclusively adapted, there are some very marked exceptions. For instance, the potato, corn (maize), and tobacco were indigenous only on this continent. Their transfer to Europe has been an untold benefit to its teeming population. The transfer to England, in the seventeenth and eighteenth century, of some of

the grasses indigenous in Virginia and Maryland, rendered it in large measure possible to make the hay in abundance, which has been noted near the beginning of this article, and which was the prime cause of the modern development of the cattle industry. The planting of the Eucalyptus tree, indigenous in Australia, has been a boon to treeless Southern California. We need not to be reminded that nearly all our cereals as well as our domestic animals are of European or Eastern origin. These illustrations cover broad lines, but they are sufficient to establish the fact that the securing of new seeds and plants for distribution is a paying investment properly conducted. On the other hand, it is equally as susceptible of demonstration that the distribution of valuable seeds and plants, not new, but well known, from one locality to another, is promotive of a higher and better production. Taken from a locality where they succeed at their best estate, they carry with them to their new home some of the impulse and vitality they took on where they were grown. This is nature's secret at the bottom of the benefits in "change of seed."

Recognizing these facts (based, as has been noted, on scientific reasons), Congress for nearly fifty years has appropriated funds for the purchase and distribution of new and valuable seeds and plants, and has committed the duty of carrying on the work to the Department of Agriculture. While it is conceded that many mistakes have been made and some notable failures have occurred, the fact remains indisputable that great benefits have been conferred upon the agriculture of the United States by the distribution. We can, out of many, give only a few illustrations. Take one from the Seed Division, that of the wheats sent out. Many kinds have been distributed. The most of them appear in the list of those now cultivated, but the number disseminated is of little importance compared with the prominence of some of them in the wheat growing of the present day. The variety which has the widest distribution is the "Fultz," a red winter wheat, which originated in Pennsylvania, and was distributed in 1871 and subsequent years. The area now occupied by it is four times as much as that devoted to any other wheat, and probably occupies one third of the area seeded in winter wheat, producing at least one fourth of the wheat harvest of the country. The next in extent is the "Mediterranean." This was imported by the Department twenty-five years ago and for several subsequent seasons from Marseilles, France, and grown on the islands of the Mediterranean Sea. The next was the "Fife." It is almost as prominent among spring wheats in the proportion of its cultivation as is the Fultz in the domain of winter wheats. It is the great wheat of the Northwest, introduced by the Department. The next and fourth in importance is the "Clawson," so well known in Michigan. Many more might be mentioned, taking a lower rank,

but which are leading varieties in many localities. The four named yield nearly or quite one half of our usual crop. Last year the Department distributed seven home varieties and four new imported ones. The home varieties consisted of three new improved ones and four of more than local celebrity, to be transferred to the localities in which they were not grown. Of the four imported two were of Black Sea and Italian parentage, for our Southern States, and two of English and French parentage; all raised in and thoroughly acclimatized to France. It is hoped that out of the four we may find at least one substantial acquisition. They all may prove failures. That is the reason why the experiment is called empirical, having as it does a large element of chance in it, though careful study was made of the strain, of the varieties, and the conditions of production.

So much for the Seed Division, though illustrations too numerous for this article suggest themselves. Let us take one or two from the work of the Horticultural Division. This deals largely, of course, with plants. It first introduced the Russian apple, which has such rare success in the West and North. It introduced the Japan persimmon, which has become so largely cultivated in Florida and California. The celebrated Washington navel orange of California was propagated from a tree growing in the hothouse of this Department. Those who have seen this wonderful orange grow will concur in the statement one repeatedly hears in California, that the introduction of this one variety was worth more to the country than the total cost of the Department of Agriculture. The original plant came from Bahia, Brazil. It took three years and two failures before success was attained, and then only in rearing a single tree, from which has come such a progeny. We can not stop to enumerate the catalogue of fruits and plants and fibers introduced, of the pineapple, olives and figs, dates, and citron. We will stop, however, long enough to speak of the citrons and figs recently imported by the Pomological Division, and of the date palms from Egypt, just distributed in California and Arizona, and upon which great expectations hang.

The Botanical Division is specially charged with the experiments with the grasses and other forage plants. During the existence of the Department the Seed Division gave much attention to the distribution of grass seeds, but it is not till within the last two years that the thorough and exhaustive experiment has been assigned to a division which shall make it a specialty. It is believed that the era which was inaugurated by the English experimenters, heretofore noted, can be repeated; that they did not exhaust the subject; that new grasses and forage plants can be found that will successfully enlarge the list. Another reason for entering upon the work is that the results of the English experiment accrue only to a comparatively

small portion of the United States. The conditions south of Virginia and Kentucky and west of the Missouri River are so different that the staple forage plants will not thrive in economic production. The South needs a new line of grasses as much as did England in the sixteenth century, and for substantially the same reason. The Great West, which is developing so rapidly, presents altogether another problem. All the grasses known to us in the North have been practically discarded there and others are supplanting them. The list is at present small, even under irrigation, and the hope is that it may be largely increased; while without irrigation there is as yet no known grass that will succeed under cultivation. Perhaps two thirds and more of that vast territory is not susceptible of irrigation. A considerable portion of this area is covered with native grasses of limited production that close and continuous pasturage destroys, leaving nothing in its place.

It is believed that from those native grasses, from those in Siberia, in India, and in South America, some varieties may be found that shall "stick" and thrive permanently, thereby quadrupling at least the production. It will doubtless take many years to accomplish this. It took England fifty years to develop her grass industry. Long before the expiration of half that time the advancing tide of population will utilize the results of these experiments, if successful, without in any sensible degree affecting the value of the products of the older and more thickly populated States. It is wise statesmanship to anticipate the wants of the future, and to determine how far it is practicable to make homes for the teeming millions to come. The Department of Agriculture is for the whole country, and should canvass the wants of all. The South, if these experiments prove a success, will find in them the means of restoring her sterile acres, and of preventing further depletion of her soil, and at the same time of developing an industry that shall make her more self-sustaining. The West may gradually force back the lines of the desert, and with grass to temper and forest trees to resist, may hope to modify the blizzards.

The economic.—This is the second branch of the experimental work. This characteristic may be found in all, but in a less degree than in the Chemical Division. The most marked feature of this division in this line is its work on the sugar question. This experiment and investigation is one of long standing. A large amount of work was done to determine whether there was sufficient saccharine matter in cornstalks to produce sugar with a profit. It was finally decided that there is not. Then, or in a measure concurrent with the corn experiments, began a long line of tests on sorghum; first, to determine the variety, the richest in saccharine qualities; second, to find the period of maturity productive of the largest yield, and at what stage of its growth the sugar would crystallize most readily,

and with least loss in molasses. The cane upon which these tests were made was planted, cultivated, and gathered under the supervision of the division. Both objects were satisfactorily determined, and for a time it looked as though the general production of sugar from sorghum would prove a success, but the price of raw sugar in the market took a large decline, so great that sugar from sorghum could not be economically produced, resulting in the collapse of the new industry, as well as that of the manufacture of glucose, a bastard sugar with which the genuine was adulterated. The experiments continued, however, taking the form of improving cane by careful scientific cultivation and propagation, so that the yield of sugar might be increased, and in determining what localities, if any, were adapted to its economic production. Considerable success has attended the work. The quality of the cane has been sensibly improved, and the regions of highest production pretty well defined; but at this date the promise for a general sorghum-sugar industry does not equal the high hopes of its most sanguine promoters, though it promises to be a success in a restricted locality. The experiment, however, has proved a most valuable one, even where it has failed, worth all and more than it cost, in that it has been demonstrated that sugar in unlimited quantities at a price but little above the cost of foreign sugars can be manufactured, so that in case of national emergency or scarcity abroad our country may be amply supplied with home products.

If the maxim "In time of peace prepare for war," is a good one in a military sense, it is no less so in an economic. A great deal of scientific work has been done in the analysis of the cane, in the study of all the processes of extracting the juice and its manufacture, in the improvement of the machinery and apparatus, in the elimination of waste by new methods and new processes, so that a full knowledge of the conditions and the possibilities of the industry has been obtained. These experiments have not been limited to sorghum cane, but have covered that of the sugar cane of Louisiana. With the latter the improvement is so marked that it is worthy of special note. The industry in Louisiana has been of so long standing that comparisons can be made. It has been proven that by modern processes developed with the coöperation of the division, and in many respects under its direct instruction, the yield of sugar from a given average ton of cane can be raised from 120 to 200 pounds, the difference of 80 pounds being lost in the operation conducted according to the old methods. When the new processes shall be applied by all the cane-sugar producers, an increase of product in the area of present cultivation would be effected to the value of more than $10,000,000 annually. These results from both the sorghum and the cane experiments amply justify the work and the expenditure. These experiments still continue, and in addition, under direction of Congress,

he cultivation of the sugar beet, and the manufacture of sugar therefrom, have been taken up. A large amount of the best seed from Europe has been obtained and distributed in the localities supposed to be best adapted to their growth, and analyses of the beets from a wide region of country are being made. At this writing the most flattering hopes are excited from the showing made. The previous work done with sorghum and sugar cane makes the transition to the beet sugar inquiry an easy one, and its solution will be more rapid, intelligent, and satisfactory.

II.—THE REMEDIAL.

Vegetable and animal life are subject to similar conditions. A tree and an animal live essentially on the same elements. They both grow to maturity, and in due time die and decay. Both have their enemies and their diseases. There are diseased cattle and diseased vines. No one speaks of a diseased granite block. It is this life and its conditions, therefore, that has its enemies and its diseases. Anything that saps or stops nutrition is an enemy to life, and may be the cause of disease. Growth stopped, decay begins, and death ensues. Kill the enemies, stay the disease, and life continues to maturity and production. Whatever kills the enemy is a remedy, whatever stays the disease is a cure. Neither adds a particle to the inherent life. Both simply remove obstructions and life goes on. The means and methods of killing the enemies and curing diseases are *remedial*, and a large part of the work of the Department is the study of these remedies. The Division of Entomology is charged with the killing of the animal enemies that attack plant and animal life; the Division of Vegetable Pathology, with remedies for the diseases of plants; the Bureau of Animal Industry, the diseases of animals. We will discuss the work of the last two first.

Manifestly the most logical way is first to find the cause of the disease, then the work of finding a remedy is simplified; the finding of the cause in very many cases suggests the remedy. It is true that experiment often finds a remedy, but with great waste of time and energy if the cause is unknown. What is the cause of plant disease? What is "pear blight?" What is "peach yellow," or "apple scab," or "black rot" in the vine? What is that "vine disease" which goes through a vineyard as a "flame of fire?" What is "rust" in wheat? What is "potato rot?" What is "mildew?" Again, what is the cause of diseases in animals? What is "hog cholera," or "swine plague," or "pleuro-pneumonia," or "Texas fever," or "tuberculosis," or "glanders," or "horse distemper?"

Now, modern science has gone far toward demonstrating that the ultimate cause of all these diseases and many not named is an infinitesimal "germ" or "spore." This germ or spore has a mysterious life of its own that attacks the life of the plant or animal.

It attaches itself to the plant, and as a fungus sucks out its vitality. It enters the sap and destroys its nutritious qualities. It enters the blood, and curdles it as it were by its marvelous power of reproduction, till the "issues of life" are spent.

There is, however, a dispute, notably relating to plant diseases, as to whether these germs are the real cause of the disease, whether they are not in fact an effect. Worms, say one side, eat the dead body, not the live; mold takes hold of decaying not living wood. These spores attack only the dead or dying. The disease antedates the attack. Vultures will follow all day long the wounded deer to pounce upon him perhaps before his last expiring breath. So do these minute spores follow the decaying vitality of the seemingly vigorous plant, which is, in truth, moribund. In other words, that this fungus never troubles, or rather thrives on an absolutely healthy vine, but that the vine is in process of decay, though it may not seem so to the eye.

On the other hand, it is as emphatically claimed that it does attack healthy plants; that in the same orchard or vineyard, in the same row, where all grow in the same soil and are in the same condition of apparent health, growth, and vitality, one will be attacked and the other left; that the disease can be produced at will in healthy plants by inoculating the virus, that is the spore, into the sap; which facts would seem to settle the controversy in their favor. Whether it does or not, there can be no question that these spores either are the cause of death or hasten it, so that if they are killed before they have got in their work, the life is in one view saved, in the other prolonged. In either case the remedy is fruitful. The experiments of the Division of Vegetable Pathology fully establish this fact.

This diversity of opinion does not exist to the same extent, relative to the germ or spore existing in animal diseases. It is true, nevertheless, that it is claimed that many of the maladies are caused by the lack of vitality in the subject, by which it is unable to resist the attacks of the germs already in the system; that a healthy body has the ability to keep them in subjection, but any derangement, sometimes a simple cold and the hitherto inert forces take new life, and attack some vital part. It is manifest, however, that this theory will not account for diseases of a contagious type where an epidemic prevails, which travels over lines as well defined as a blizzard, striking down indiscriminately the strong and the weak, the apparently healthy as well as the unhealthy. There is, however, an unsolved mystery in the ways of these unseen messengers of death; one is taken and another is left, even under like exposure and apparently like conditions. If it be proved as claimed, that the causes of these diseases is a living germ, substantial progress has been made. They have form and substance and life, and it is a relief from the terror inspired by the conception that the cause is something in-

tangible as a spirit, impalpable as a ghost, but withering as a blast from the infernal regions. There is hope in the knowledge that these spores are living organisms, for it is almost axiomatic that every living thing can be killed. It may be by some poison, mineral or vegetable, by some substance that destroys the tissue in which it lives, by some parasite harmless to the animal but deadly to the germ, by the frosts of winter, by fire, fumigation and purification, whereby the nests in which it is bred, are wholly destroyed. It is believed that, as the next step, now that the cause is known, science will in time in each case find the remedy that shall kill the germ without killing the animal. It is a matter of some discouragement that up to date we have not been able to exterminate pleuropneumonia except in the destruction of the animal infected, but public attention has been sharply arrested on this point, and some of the ablest men of the world are investigating the problem. In the two divisions under consideration, experts are studying in all their forms and phases these germs or spores that prey upon animal and vegetable life. In the laboratory, in the field, with microscopes, with germ culture, with fungicides, with vaccination of other or similar, but less injurious germs, and in every way that science can suggest, or experiment can blaze the way, remedies are being sought, and in time, as before said, will be found in some form or other, as by Jenner for smallpox, Pasteur for hydrophobia, and Koch for tuberculosis.

The work of these two divisions, however, is not limited to this strictly scientific investigation. In the Division of Vegetable Pathology some of the experiments with fungicides have brought substantial results. A striking example bearing on this point is shown in the method of dealing with black rot of the grape. Before this disease was investigated by the Department, nearly every grape grower had a theory as to the cause of it, but the question of a remedy was entirely beyond the imagination of the most sanguine. By scientific investigations which covered months, it was shown that the disease was due to a microscopic fungus, and that the fungus passed through several stages. The character and life history of the fungus was determined, and this knowledge suggested the remedy which, when applied intelligently, can save the crop. Many farmers and fruit growers who have followed the instructions of the Department this year have saved from 80 to 90 per cent. of their crop, while there was almost a total failure in the portions of the vineyards untreated. Reports of this season's work justify the statement that in this one line more has been saved by the comparatively few who followed instructions than the total expenditure of the division in all lines. The division has had under investigation a large line of plant diseases, chief among which are "peach yellows," "pear blight," "apple and pear scab," "pear and cherry leaf blight," the "California

vine disease," "cotton anthracnose," "anthracnose of the hollyhock," a bacterial disease of the oat which is destroying millions of bushels, "rots" of the sweet and Irish potatoes, "mildew" and "anthracnose of the grape." In some the causes are still unknown or obscure. Others are perceptibly yielding to treatment, and there are high hopes of essential success in the near future.

The Bureau of Animal Industry was specially charged in 1886 with the eradication of pleuropneumonia among cattle, which at that time was so widespread and so terribly destructive. With a large force, mainly of veterinary experts, it attacked the disease, and has essentially stamped it out. To form some idea of the work done (and it was essentially scientific in its character), we need only to note the fact that from August 1, 1886, to November 30, 1888, there were inspected by the agents of the Bureau 50,838 herds, containing in all 300,737 cattle; there were found 1,428 infected herds, which contained 5,715 infected animals, and there were made 49,073 post-mortem examinations. Whenever a herd was found infected, or had an infected animal in it, it was at once quarantined, the infected animal slaughtered, and in fact large numbers of animals exposed to the contagion were likewise slaughtered and paid for by the Department. This work enlisted in its service the highest attainable skill in the country; for large interests were at stake, large sums of money expended, and a terrible evil was to be extirpated. That success has been attained is due in a large measure to the scientific work of the Department. In but one or two localities are there now any appearances or suspicions of the disease, and strict quarantine is still being made of all suspected animals. This is necessary for the reason that the germs of the disease may still exist in an undeveloped state, which on some propitious occasion will show itself and begin its devastating work. It is said that notwithstanding large expenditures of money in foreign countries, whence came the disease, nowhere has it been entirely eradicated; so, constant vigilance is required, not only to watch the least symptoms of revival of it here, but to prevent the importation of infected animals.

Entomology.—A large portion of our injurious insects are of foreign origin. We are the asylum of every downtrodden race of men, good, bad, and indifferent, and they bring with them from every clime the diseases and the insects incident to their countries. The result is that we are in number and variety the most pest-ridden country of the world. The Hessians are reputed as bringing with them the Hessian Fly, and it is not discrediting the Hessian soldier to say that the Hessian Fly has done far more harm to the country than did the soldier. George Washington could take him prisoner, but a generation could not capture the fly. The work, therefore, of the Division of Entomology is the most varied of any connected with the Department. When we take into account the fact that there are

already listed nearly or quite three hundred thousand varieties of insects, only a small portion, it is true, injurious to agriculture, but a large portion likely at any time to become so by some change of temperature, some change or increase in the humidity of the climate, or some want of its natural source of sustenance, which may precipitate them in countless hordes upon growing fields, the importance of the science of entomology will be so obvious as to lift it into public consideration. A universally effective insect powder would command as ready sale as a well advertised patent medicine. Insects are the scourge of every farmer and fruit grower, and the life-long plague of every thrifty housewife. The work of this division has been so constant in studying their life history and characteristics, and the means of checking their ravages, that it could hardly have failed, if it would, in accomplishing great good for agriculture. The information given as to remedies has been so ample, and the instructions as to methods of application have been so full, that it is needless to specify the particular instances of special benefit. The sum and substance of the instructions is to kill the insect and yet not kill the plant or animal or substance it infects. The experiments in insecticides and their application by spraying machines have been invaluable. These experiments have not been haphazard, but have been guided by scientific discrimination. One illustration will suffice. The persistent efforts of this division to discover a remedy for the ravages of the scale insect among the orange groves of California—ravages which in a short time from their beginning threatened to destroy this most promising branch of agriculture—have been crowned with success. It was due to the efforts of this division that a skilled entomologist was sent to Australia, where he discovered a parasite to the pest, though Australian scientists had denied its existence, and having discovered it brought home a supply for propagation in California. California fruit growers have asserted that the investigations and experiments have saved their oranges.

III.—GENERAL SCIENTIFIC WORK.

The Chemical Division has been conducting an important and fruitful series of tests to determine the extent and character of adulteration of the food, drugs, and liquors offered for sale in American markets, and has made analyses of grasses and cereals, of soils and waters, as occasion has required and the means at hand have afforded opportunity.

The Forestry Division has devoted itself to the study of the life histories of trees, and the distribution and extent of forests, the prevalence and characteristics of varieties of forest growths, and the modifications arising from differences in climate and soil, and to a series of mechanical tests and laboratory examinations to determine more satisfactorily the qualities of our many timbers, grown under

different conditions, so that the wood worker and user may more intelligently make his choice of timbers from different localities and for different purposes.

In the Division of Ornithology the whole question of distribution of plants and animals, the food habits of birds and mammals, and the relation of these to agriculture, horticulture, and forestry has been primarily considered, and much valuable fieldwork has already been performed. The results to be obtained can be hardly less important than those already referred to as accomplished and hoped for in connection with the distribution of cereal, vegetable, fruit, and grass seeds by the Department for economic purposes. An accurate survey showing, as regards altitude and latitude, the habitat of any given indigenous species will serve to the scientist as a starting point for the consideration of the multitudinous questions brought to his attention with respect to the adaptability of any given locality to the growth of any given economic plant. In this study the Botanical, the Pomological, and the Forestry Division are contributors.

The Division of Pomology is creating for itself a wide field of usefulness in connection with the study of varieties of fruits and the effect of change from a given climate and soil to another, and the Botanical Division is engaged in a similar work in respect to plants and grasses. The National Herbarium, under the control of the Botanical Division, is winning recognition and approval from the botanists of the world, both by reason of the extent of its collections and the excellence of its system of classification.

The Entomological Division has for its scientific function the collection and classification of insects and the study of the conditions which promote or retard their increase and of their capabilities of usefulness or mischief. The reputation of the division among scientific men was world-wide years ago, and it has suffered nothing in standing or reputation of late years.

The study of the habits of the silkworm is now pursued in the Silk Section, and forms the chief scientific function of the section. The study promises to result in the distribution of the best varieties of the worm.

The Microscopical Division is rendering valuable public service by applying the microscope to the study of food adulteration and the character of textile fibers.

Important scientific work has been performed by a special agent of the Department in relation to the adaptability of some of the most economic fiber plants to growth in different sections of the country, and practical results of the study have been embodied in publications setting forth suggestions as to the best methods of cultivation, decortication, and separation from woods and gums.

Statistical Division and Office of Experiment Stations.—If it be

true, as Comte says, that the test of a science is its power of prediction, the highest order of economic science finds full play in the Statistical Division and of agricultural science in the Office of Experiment Stations. It is said that in no one thing did Gladstone in his prime show his wonderful abilities more than in forecasting the production and revenues of England. He reasoned from the known to the unknown. The Statistical Division more than any other considers all the forces that enter into the great and varied agricultural productions in our vast domain, so that intelligence shall decide what to plant, where to plant, and when to plant. The Office of Experiment Stations is charged with the scientific work of comparing, editing, and publishing the results of the experiments made by the experiment stations, and to indicate, from time to time, such lines of inquiry as shall seem most important. It goes without saying that this work calls for the highest scientific qualities. To take a comprehensive view of the work of nearly four hundred independent workers in the scientific field, to properly digest the same for publication, and to suggest lines of work and lines of experiment requires the ablest talent the country can produce. The relations of this Department with the agricultural colleges and experiment stations are and should be very intimate. They were both born of the same impulse. The act to establish a Department of Agriculture (before that it was, as heretofore stated, a division of the Patent Office) was approved May 15, 1862. The act establishing the agricultural colleges was approved July 2, 1862. The act establishing agricultural experiment stations was approved March 2, 1887. The bill to make this Department one of the Executive Departments of the Government was pending at that date before Congress, and had passed the House of Representatives, and finally became an act, approved February 9, 1889. The historian will recognize the significance of this coördinate legislation. It means a movement all along the lines of science applied to agriculture. These colleges and experiment stations are nurseries of applied science.

This article will have failed of its object if it does not satisfy the most skeptical that this Department in applying its scientific work to the wants of the great industry it represents, is fully abreast with the marching columns of this new movement.

REPORT OF THE CHIEF OF THE BUREAU OF ANIMAL INDUSTRY.

SIR: I have the honor to transmit herewith my report, which contains a brief statement of the more important work accomplished by the Bureau of Animal Industry during the year 1890. For many interesting details of the work, and for the reports of agents, inspectors, and other employés, I must refer you to the Sixth Annual Report of the Bureau of Animal Industry.

Very respectfully,

D. E. SALMON,
Chief of the Bureau of Animal Industry.

Hon. J. M. RUSK,
Secretary of Agriculture.

PLEURO-PNEUMONIA.

The year has passed without any discovery of contagious pleuro-pneumonia outside of the districts which were recognized in the last report as infected. The regulations of the Department have been enforced without difficulty, and the progress of the work for the eradication of this plague has been continuous and rapid.

No cases of the disease have occurred in the State of New York except on Long Island. No cases have been discovered in Pennsylvania during the year, although a constant inspection has been maintained. The last case discovered in Maryland occurred in October, 1889, and since that time the State has been free from all evidence of the contagion. The condition of New Jersey as regards this plague has also improved rapidly. No other States have been affected.

The efficiency of the regulations and of the methods employed under them is demonstrated by the fact that for two years there has not been a case of the disease outside of the very restricted areas on the Atlantic seaboard which have from the first been recognized as infected. These regulations are still in force, and with the almost complete eradication of the contagion the danger of any infection extending to other sections has practically disappeared.

WORK IN NEW YORK.

In order to hasten the work on Long Island more radical measures of disinfection were adopted early in the year and in certain cases where the disease had reappeared several times stables were torn down and burned. It also became necessary in order to maintain any respect for the Department regulations that vigorous meas-

ures should be adopted to prevent cattle from grazing upon the commons in the infected district. There appeared to be a widespread opinion, fostered by interested parties, to the effect that the Department had no power to enforce its regulations. As the total eradication of the disease could never be accomplished while the cattle of the infected districts were allowed to pasture in common and mingle together on the pastures and highways, it was determined to put a stop to this practice by seizing and slaughtering all cattle found off of the owners' premises without a permit from the chief inspector. The first seizure included over one hundred head of cows, and this was followed by others at short intervals. The owners, however, soon discovered that it was to their interest to abide by the regulations and from that time the disease has rapidly disappeared. There can be no doubt but that these measures, though they appear arbitrary and severe, were the means of bringing speedy success to the work on Long Island, when before their adoption there was reason to fear that the contagion might still linger there for an indefinite time.

From July 1, 1889, to June 30, 1890, there were inspected in New York 17,767 herds, containing 147,988 head of cattle. There were 151,284 animals reëxamined and 34,905 were tagged with numbers and registered upon the books of the Bureau.

There were 128 new herds found affected with pleuro-pneumonia during the year, and these herds contained 2,879 animals, 182 of which were pronounced diseased when the inspections were made. There were purchased for slaughter during the same time 603 affected cattle at a cost of $15,756.37, an average of $26.13; also 2,513 exposed cattle at a cost of $55,744.54, an average of $22.18. The smaller cost of the exposed cattle was due, as in previous years, to the fact that the amount which the owner realized for the carcasses was deducted from the appraised value, the Department paying the balance.

It has been found necessary to disinfect 416 stables, stock yards, or other premises during the year, and also to make *post-mortem* examinations upon 17,109 carcasses of bovine animals, of which 631 were found diseased with pleuro-pneumonia.

The total expenses in New York from July 1, 1889, to June 30, 1890, were $174,952.48, of which $71,500.91 was paid for cattle purchased for slaughter as either diseased or exposed. The remainder constitutes the cost of disinfection, inspection, tagging, registering, supervising the movement of cattle, *post-mortem* examinations, and all the various expenses incident to a work of this character.

WORK IN NEW JERSEY.

In this State the active work has been almost entirely confined to Hudson County. The diseased herds discovered have not been numerous, and both affected and exposed animals have been promptly slaughtered.

From June 30, 1889, to July 1, 1890, there were inspected in New Jersey 8,624 herds, containing 64,108 head of cattle. Of this number 40,305 were reëxamined and 9,780 were tagged with numbers and registered upon the books of the Bureau.

There were 29 new herds found affected with pleuro-pneumonia during the year, and these herds contained 405 animals, 46 of which were pronounced diseased at the time the inspections were made. There were purchased for slaughter during the same time 69 affected

cattle at a cost of $1,848.50, an average of $26.79 per head; also 451 exposed cattle at a cost of $10,947.75, an average of $24.27 per head.

It has been found necessary to disinfect 167 stables, stock yards, or other premises, and also to make *post-mortem* examinations upon the carcasses of 10,741 bovine animals, of which 89 were found diseased with pleuro-pneumonia.

The total expenses in New Jersey from July 1, 1889, to June 30, 1890, were $60,828.02, of which $12,896.25 was paid for cattle purchased for slaughter because they were either diseased or had been exposed.

WORK IN MARYLAND.

Although the last case of pleuro-pneumonia was discovered in Maryland in October, 1889, it was deemed best to keep up the inspection for a considerable time in order that there might be a certainty of the complete extermination of the disease. Quarantine restrictions were removed May 1, 1890, but inspections have been continued, and it may now be definitely announced that Maryland is free from the contagion.

From July 1, 1889, to June 30, 1890, there were inspected in Maryland 7,296 herds, containing 71,503 head of cattle. Of this number 8,368 were reëxamined and 10,298 were tagged with numbers and registered upon the books of the Bureau.

There were 2 new herds found affected with pleuro-pneumonia during the year, and these herds contained 28 animals, 2 of which were pronounced diseased when the inspections were made. There were purchased for slaughter during the same time 4 affected cattle at a cost of $99.19, an average of $24.80 per head; also 69 exposed cattle at a cost of $1,115.01, an average of $16.16 per head.

It was found necessary to disinfect 5 stables or other premises during the year and to make *post-mortem* examinations upon the carcasses of 15,109 bovine animals, of which 4 were found diseased with pleuro-pneumonia.

The total expenses in Maryland from July 1, 1889, to June 30, 1890, were $38,558.17, of which $1,214.20 was paid for cattle purchased for slaughter as either diseased or exposed.

THE WORK AS A WHOLE.

Including all the districts in which pleuro-pneumonia has existed there were inspected from July 1, 1889, to June 30, 1890, a total of 33,687 herds of cattle, containing 283,599 animals. Of this number 199,957 were reëxamined, and 54,983 were tagged with numbers and registered upon the books of the Bureau.

There were 159 new herds found affected with pleuro-pneumonia during the year, and these herds contained 3,312 animals, 230 of which were pronounced diseased when the inspections were made. There were purchased for slaughter during the same time 676 affected cattle at a cost of $17,704.06, an average of $26.19 per head; also 3,033 exposed cattle at a cost of $67,807.30, an average of $22.36 per head.

It has been found necessary to disinfect 588 stables, stock yards, or other premises, and also to make *post-mortem* examinations upon the carcasses of 42,959 bovine animals, of which 724 were found diseased with pleuro-pneumonia.

The total expenses of the pleuro-pneumonia work from July 1, 1889, to June 30, 1890, have been $274,338.67, of which $85,511.36 was paid for cattle purchased for slaughter as either diseased or exposed.

The remainder constitutes the expense for inspection, disinfection, tagging, registering, and supervising the movement of cattle, of *post-mortem* examinations, and of all the various expenses necessary to insure the prompt discovery of this plague when it appears in any herd and prevent the further extension of the infection.

The following table gives a résumé of the pleuro-pneumonia work from July 1, 1889, to June 30, 1890, as given in detail above:

	New York.	New Jersey.	Maryland.	Total.
Herds inspected	17,767	8,624	7,296	33,687
Cattle inspected	147,988	64,108	71,503	283,599
Cattle reëxamined	151,284	40,305	8,368	199,957
Diseased cattle found by inspection	182	46	2	230
Post-mortem examinations	17,109	10,741	15,109	42,959
Diseased carcasses found	631	89	4	724
Cattle tagged	34,905	9,780	10,298	54,983
New herds found affected	128	29	2	159
Animals in affected herds	2,879	405	28	3,312
Diseased cattle purchased	603	69	4	676
Exposed cattle purchased	2,513	451	69	3,033
Premises disinfected	416	167	5	588

A résumé of expenditures in the pleuro-pneumonia work for the same period is made below:

Items.	New York.	New Jersey.	Maryland.	Total.
Salaries	$82,386.60	$35,583.31	$30,139.62	$148,109.53
Traveling expenses	12,619.26	10,323.16	6,366.08	29,308.50
Miscellaneous expenses	8,445.71	2,125.30	838.27	11,409.28
Affected cattle	15,756.37	1,848.50	99.19	17,704.06
Exposed cattle	55,744.54	10,947.75	1,115.01	67,807.30
Total	174,952.48	60,828.02	38,558.17	274,338.67
Average for affected cattle	26.13	26.79	24.80	26.19
Average for exposed cattle	22.18	24.27	16.16	22.36

COMPARISONS WITH PREVIOUS YEARS.

The progress accomplished by this work can not be appreciated without comparing the number of new herds found affected during the year, and the total number of cases of pleuro-pneumonia found on *post-mortem* examination with similar data gathered from the reports of preceding years. As all carcasses of animals which have died or which have been slaughtered in the infected districts are carefully examined, we have in the returns of the *post-mortem* examinations the total number of cases of pleuro-pneumonia which have occurred.

The number of cattle and of new herds found affected with pleuro-pneumonia on *post-mortem* examination during the year ending June 30, 1890, as compared with the preceding year is as follows:

States.	Affected cattle.		Affected herds.	
	1889-'90.	1888-'89.	1889-'90.	1888-'89.
New York	631	1,561	128	235
New Jersey	89	302	29	91
Pennsylvania	....	29	....	7
Maryland	4	242	2	46
Total	724	2,134	159	379

The total number of diseased and exposed cattle which have been purchased and slaughtered each year since the work for the eradication of pleuro-pneumonia was commenced is shown by the following table. The figures are for the fiscal year ending June 30.

	1886-'87.	1887-'88.	1888-'89.	1889-'90.	Total.
Diseased	1,342	2,398	1,903	676	6,319
Exposed	1,576	5,345	4,583	3,033	14,537

These tables show a very marked decrease of the disease. There were not half as many new herds found affected in 1889-'90 as in the preceding year, and only about one-third as many affected cattle. The largest number of cattle were slaughtered in 1887-'88, as previous to this the work had not covered the whole of the infected district. Since that time the number slaughtered has been largely decreased each year. The eradication of the disease has been most rapid, however, since April, 1890, the number of new herds found affected and the cases of pleuro-pneumonia found on *post-mortem* examination during the quarter being as follows:

	April.	May.	June.	Total.
Herds affected	13	5	5	23
Animals affected	33	62	9	104

This shows a gratifying improvement over the preceding months of the year, but it is only when we compare the figures for this quarter with those for the first quarter of the year 1890-'91 that we can appreciate the rapidity of our recent progress. The statement for this quarter is as follows:

	July.	August.	September.	Total.
Herds affected	2	4	3	9
Animals affected	2	13	13	28

When we add that during the month of October, 1890, no cases of disease were found it is conclusively shown that we are rapidly nearing the time when pleuro-pneumonia can be declared exterminated from the United States. Until from four to six months have elapsed after the last case of this disease has been found it will be necessary to maintain the same inspection force and to keep up the same vigilant supervision as we now have. Otherwise neither our own people nor foreign governments will be convinced of the complete success of the work.

REGULATIONS CONCERNING TEXAS FEVER.

The losses from Texas fever were so much reduced by the regulations of 1889 that a similar order was issued early in 1890 to take effect March 15. By commencing the supervision at this early date it was hoped that the infection of northern pastures might be entirely prevented and the dissemination of the disease reduced to a minimum. This anticipated relief from the fever was very generally realized,

but there were some outbreaks in Kansas which occurred from infection introduced before the regulations went into effect. This was no doubt due to the exceptionally warm winter and could not be foreseen.

The regulations, also, differed from those of 1889 by allowing no cattle from the Indian Territory or from Texas with the exception of the northern part of the Panhandle to mingle with the uninfected cattle. While it is doubtless true that the northwestern portion of the Indian Territory and a considerably larger section of Texas are free from permanent infection, the absence of local laws preventing free driving of dangerous cattle makes it unsafe to allow cattle from such districts to go into the same cars and yards as those from farther north. The full text of the order is as follows:

UNITED STATES DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., February 24, 1890.

To the Managers and Agents of Railroad and Transportation Companies of the United States:

In accordance with section 7 of an act of Congress approved May 29, 1884, entitled "An act for the establishment of a Bureau of Animal Industry, to prevent the exportation of diseased cattle and to provide means for the suppression and extirpation of pleuro-pneumonia and other contagious diseases among domestic animals," you are hereby notified that a contagious and infectious disease known as splenetic or Texas fever exists among cattle in the following described area of the United States:

All that country lying south and east of a line commencing on the Mississippi River at latitude 36° 30′ north, thence running westward on that parallel of latitude, being the southern boundary of Missouri, to the eastern boundary of Indian Territory, thence running northward to the southern boundary of Kansas, thence westward along said boundary of Kansas to the one hundredth meridian of longitude, thence southward along said one hundredth meridian of longitude to the southern boundary in Childress County in Texas, thence westward along the southern boundary of the counties of Childress, Hall, Briscoe, Swisher, Castro, and Parmer to the eastern boundary of New Mexico.

From the 15th day of March to the 1st day of December, 1890, no cattle are to be transported from said area to any portion of the United States north, east, or west of the above described line except in accordance with the following regulations: *Provided*, That these regulations shall not apply to any cattle taken into or through the State of Colorado for feeding purposes in accordance with the regulations of that State:

First. When any cattle in course of transportation from said area are unloaded north, east, or west of this line to be fed or watered, the places where said cattle are to be so fed or watered shall be set apart and no other cattle shall be admitted thereto.

Second. On unloading said cattle at their points of destination pens shall be set apart to receive them, and no other cattle shall be admitted to said pens, and the regulations relating to the movement of Texas cattle, prescribed by the cattle sanitary officers of the State where unloaded, shall be carefully observed. The cars that have carried said stock shall be cleansed and disinfected before they are again used to transport, store, or shelter animals.

Third. Whenever any cattle that have come from said area shall be reshipped from any of the points at which they have been unloaded to other points of destination the car carrying said animals shall bear a placard stating that said car contains southern cattle, and each of the waybills of said shipment shall have a note upon its face with a similar statement. At whatever point these cattle are unloaded they shall be placed in separate pens, to which no other cattle shall be admitted,

Fourth. The cars used to transport such animals and the pens in which they are fed and watered and the pens set apart for their reception at points of destination shall be disinfected in the following manner:

(*a*) Remove all litter and manure. This litter and manure may be disinfected by mixing it with lime, diluted sulphuric acid, or, if not disinfected, it may be stored where no cattle can come in contact with it until after December 1.

(*b*) Wash the cars and the feeding and watering troughs with water until clean.

(*c*) Saturate the walls and floors of the cars and the fencing, troughs, and chutes of the pens with a solution made by dissolving 4 ounces of chloride of lime to each

gallon of water, or disinfect the cars with a jet of steam under a pressure of not less than 50 pounds to the square inch.

The losses resulting yearly to the owners of northern cattle by the contraction of this disease from contact with southern cattle and through infected cars, and by means of the manure carried in unclean cars from place to place, have become a matter of grave and serious concern to the cattle industry of the United States. It is necessary, therefore, that this cattle industry should be protected as far as possible by the adoption of methods of disinfection in order to prevent the dissemination of this disease.

A rigid compliance with the above regulations will insure comparative safety to northern cattle and render it unnecessary to adopt a more stringent regulation, such as the absolute prohibition of the movement of southern cattle except for slaughter during the time of year that this disease is fatal.

Inspectors will be instructed to see that disinfection is properly done, and it is hoped that transportation companies will promptly put in operation the above methods.

Very respectfully,

J. M. RUSK,
Secretary.

It has been found that the regulation requiring a placard to be placed upon the car in which southern cattle are shipped is of little practical benefit, as shippers and others remove these marks in so many instances that this method of distinguishing infected cars cannot be relied upon. Railroad companies have, however, in nearly all cases, stamped their waybills in accordance with the regulations and this has proved sufficient for the identification of cars and cattle.

It will be noticed that the regulations thus far made have not extended east of the Mississippi River. There is no doubt, however, that the Gulf and south Altantic States are infected with this disease to the same degree as Texas, and there should be the same regulation of cattle coming from them. The traffic has been so light and the difficulties of regulating it have been such that up to the present the attempt has not been made. Before the disease can be entirely prevented it will be necessary that the line of infection shall be drawn to the Atlantic seaboard and that the same rules be enforced east of the Mississippi as were enforced west of it during the last two years. This will prevent the infection of a number of stock yards that during the present year have been centers from which the dissemination of the disease has taken place with cattle bought both for home and for export markets.

On the whole the effect of these regulations has been extremely beneficial. As compared with former years but a small amount of the disease has been reported either in the United States or among cattle shipped abroad. The losses during the ocean voyage have been so much less than usual that insurance is said by shippers to have been reduced over 50 per cent. If this statement is correct it means a saving of over a million dollars to our shippers by this reduction of insurance alone.

Since the danger of shipping export cattle infected with pleuropneumonia has been removed a number of English writers have expressed great fear of the permanent introduction of Texas fever into Great Britain by cattle from the United States. This fear certainly must be groundless and one that could arise only through ignorance of the characters of the disease. In the first place, cattle that are sick from this disease do not transmit it to other animals, and consequently affected animals which are landed on the other side may be left out of consideration as carriers of the infection. In the

second place, cattle which are shipped by cars or boat lose the infection in about three weeks after leaving their native pastures. If, therefore, the time should come when Texas cattle shall be exported to Great Britain, there would be little danger from them, as it would require fully three weeks, if not longer, to transport them. In the third place, this disease never occurs in our Northern States until the middle of summer after there has been a protracted period of intense heat, the temperature of our spring and early summer being generally insufficient to develop the disease. The summer temperature in Great Britain is probably neither high enough nor is the high temperature continued a sufficient time to allow the development of this fever.

Leaving these facts out of consideration, we should be able to prevent the exportation of any cattle that are infected, or any that are capable of disseminating the infection, by properly enforced regulations which will prevent the mingling of southern and northern cattle in our cars and stock yards. The disease is one of the easiest to prevent of any which affects our domesticated animals, and for that reason we should be able to guard against all danger from it either to our own cattle or those of other countries to which our animals are sent.

The success of the regulations during the past two years has been all that was anticipated. It has not been found difficult to identify cattle from south of the line of infection in Texas by their brands, and railroad companies have, as a rule, been prompt to clean and disinfect their cars. The principal stock-yard companies have also furnished separate pens, which have been maintained with great regard to cleanliness and the proper handling of cattle, and from every point of view it has been demonstrated that the prevention of this disease is practicable without any hardship to those engaged in the cattle traffic. Indeed, it is now asserted that southern cattle bring better prices when sold from the quarantine yards than when indiscriminately mixed with other stock, and for this reason many lots of cattle from just north of the line are sent by choice of the owners to the quarantine yards for sale.

INSPECTION OF AMERICAN CATTLE IN GREAT BRITAIN.

The rapid progress and practically complete success of the work for the eradication of contagious pleuro-pneumonia from the United States removes the cause alleged by foreign governments for the exclusion of American cattle from their countries.

Great Britain for a number of years has maintained an absolute prohibition against the introduction of American cattle into that country, and only permits their reception at the foreign animal wharves, where they are to be slaughtered within ten days after their arrival.

The several governments of the continent of Europe have also enforced a quarantine of from two to four weeks on all American cattle, which has almost entirely prevented shipments from this country.

For a number of years the British authorities have reported the arrival at their ports of American cattle affected with contagious pleuro-pneumonia, and it became, therefore, absolutely necessary that this Bureau should be represented by its own officials at the *post-mortem* examinations made on American cattle at the foreign

animal wharves in order that we should determine, to our own satisfaction, whether the lung disease found there was, as they claimed, contagious; and if it were found to be contagious, the affected animal should be traced back to the farm in this country from whence it came. With this object in view the aid of the State Department was solicited in opening negotiations through Minister Lincoln with the British Government looking to such an arrangement. Through the active coöperation of the State Department and the intelligent efforts of Minister Lincoln the privilege was obtained from the British Government of stationing three veterinary inspectors, one at each of the principal animal wharves where American cattle are slaughtered, and who would be allowed every facility in participating with the local officers in the work of inspecting and making *post-mortem* examination on American cattle landed in British ports. As soon as this privilege was secured three competent veterinary officers of the Bureau were dispatched to Great Britain in charge of the Chief of the Bureau of Animal Industry, who remained with them until their duties were clearly defined and the best means decided upon to enable them to carry on their work effectually and in harmony with the British authorities.

This work was commenced on August 16 of the present year, and from that date to November 8, inclusive, there were inspected and *post-mortem* examinations made on 104,296 head of cattle arriving in Great Britain from the United States at the several ports, as follows:

London	43,488
Liverpool	50,342
Glasgow	10,466

No indications of contagious pleuro-pneumonia were found in any of these animals, and on account of the eradication of the disease in this country it is believed that none will be found in the future.

INSPECTION OF EXPORT CATTLE BEFORE SHIPMENT.

The act of August 30, 1890, providing for the inspection of all export cattle, sheep, and swine, has enabled this Bureau to introduce a system of tagging export cattle by means of which it will be possible to determine the section of the country from which any animal has come that may be found at a foreign port affected with any disease. This act also prevents the exportation of any diseased animals. The amount of work required to carry out this inspection may be comprehended by the fact that during the year ending June 30, 1890, the number of animals exported was as follows:

Cattle	394,836
Hogs	91,148
Sheep	67,521

The following rules and regulations under the tenth section of the above named act were prescribed by the Secretary of Agriculture on October 20, 1890:

Order and Regulations for the Inspection of Cattle and Sheep for Export.

UNITED STATES DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., October 20, 1890.

The following order and regulations are hereby made for the inspection of neat cattle and sheep for export from the United States to Great Britain and Ireland and the continent of Europe by virtue of the authority conferred upon me by section

10 of the act of Congress approved August 30, 1890, entitled "An act providing for the inspection of meats for exportation, prohibiting the importation of adulterated articles of food or drink, and authorizing the President to make proclamation in certain cases, and for other purposes:"

(1) The Chief of the Bureau of Animal Industry is hereby directed to cause careful veterinary inspection to be made of all neat cattle and sheep to be exported from the United States to Great Britain and Ireland and the continent of Europe.

(2) This inspection will be made at any of the following named stock yards: Kansas City, Missouri; Chicago, Illinois; Buffalo, New York; Pittsburgh, Pennsylvania; and at the following ports of export, viz: Boston and Charlestown, Massachusetts; New York, New York; Philadelphia, Pennsylvania; Baltimore, Maryland, and Norfolk and Newport News, Virginia. All cattle shipped from any of the aforesaid yards must be tagged before being shipped to the ports of export. Cattle arriving at ports of export from other parts of the United States will be tagged at said ports.

(3) After inspection at the aforesaid stock yards all cattle found free of disease and shown not to have been exposed to the contagion of any contagious disease will be tagged under the direction of the veterinary inspector in charge of the yards. After tagging the cattle will be loaded into cleaned and disinfected cars and shipped through from said yards in said cars to the port of export.

(4) All animals will be reinspected at the port of export. All railroad companies will be required to furnish for the transportation of cattle and sheep for export clean and disinfected cars, and the various stock yards located at the ports of export shall keep separate clean and disinfected yards for the reception of export animals only.

(5) Shippers will notify the veterinary inspector in charge of yards of intended shipments of cattle, and will give to the said inspector when possible the name of the locality from which said animals have been brought and the name of the feeder of said animals, and such further and other information as may be practicable for proper identification of the place from which said animals have come.

(6) The inspector, after passing said cattle and tagging the same, will notify the veterinary inspector in charge of the port of export of the inspection of said animals, giving him the tag numbers and the number and designation of the cars in which said animals are shipped.

(7) Export animals, whenever possible, shall be unloaded at the port of export from the cars in which they have been transported directly at the wharves from which they are to be shipped. They shall not be unnecessarily passed over any highway or removed to cars or boats which are used for conveying other animals. Boats transporting said animals to the ocean steamer must be first cleansed and disinfected under the supervision of the veterinary inspector of the port, and the ocean steamer must before receiving said animals be thoroughly cleaned or disinfected in accordance with the directions of said inspector. When passage upon or across the public highway is unavoidable in the transportation of animals from the cars to the boat it must be under such careful supervision and restrictions as the veterinary inspector may in special cases direct.

(8) Any cattle or sheep that are offered for shipment to Great Britain or Ireland or the continent of Europe, which have not been inspected and transported in accordance with this order and regulations, will not be allowed to be placed upon any vessel for exportation, as they will be deemed under the law to have been exposed to infection so as to be dangerous to other animals.

(9) The supervision of the movement of cattle from cars and yards to the ocean steamer at the ports of export will be in charge of the veterinary inspector of the port. No ocean steamer will be allowed to receive more cattle or sheep than it can comfortably carry. Overcrowding will not be permitted.

(10) The veterinary inspector at the port of export will notify the collector of the port of the various shipments of cattle or sheep that are entitled to clearance papers, and certificates of the inspection of said animals will be given to the consignors for transmission with the bills of lading.

J. M. Rusk,
Secretary.

This work was inaugurated at the various ports of export named in the regulations on or about the 17th of November, and from that date up to the 28th of said month there have been inspected and

tagged 12,055 head of export cattle from the different ports, as follows:

Boston	3,703
New York	3,893
Philadelphia	518
Baltimore	2,559
Newport News	1,197
West Point, Va	185

The work of inspecting and tagging at the interior stock yards named in the regulations commenced on or about the 1st day of December, and the entire system as adopted is now in full running order.

INSPECTION AND QUARANTINE OF IMPORTED ANIMALS.

Regulations for the quarantine of neat cattle from the countries not located on the American continent continue to be enforced. The period of quarantine—three months—is regarded as amply sufficient under the regulations to prevent the introduction of disease, and no additional restrictions have been imposed, notwithstanding the fact of the restrictions imposed by Great Britain on cattle from this country and the additional fact that pleuro-pneumonia is much more prevalent and widely spread in Great Britain than it ever was in the United States.

There has long been danger of the introduction of foot-and-mouth disease by the importation of sheep, swine, and other susceptible animals that have heretofore been allowed to land without either quarantine or inspection; indeed this disease has several times been brought to this country by cattle from Great Britain, but it has fortunately been detected in time to prevent its dissemination here. Notwithstanding this fact our sheep have been excluded from Great Britain for more than ten years owing to the alleged existence of this disease in the United States, where it has never been seen except when brought by British cattle that were affected before landing.

In order to avoid any danger of the introduction of this disease from foreign countries into the United States the Secretary of Agriculture, under the provisions of the act of August 30, 1890, prescribed on October 13, 1890, the following regulations for quarantine and inspection of all neat cattle, sheep and other ruminants, and all swine imported into the United States:

Regulations for the Inspection and Quarantine of Neat Cattle, Sheep and other Ruminants, and Swine, Imported into the United States.

UNITED STATES DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., October 13, 1890.

In pursuance of sections 7, 8, and 10 of an act of Congress entitled "An act providing for the inspection of meats for exportation and prohibiting the importation of adulterated articles of food or drink, and authorizing the President to make proclamation in certain cases, and for other purposes," approved August 30, 1890, the following regulations are hereby prescribed for the inspection and quarantine of neat cattle, sheep and other ruminants, and swine, imported into the United States:

(1) With the approval of the Secretary of the Treasury the following named ports are hereby designated as quarantine stations, and all cattle, sheep and other ruminants, and swine imported into the United States must be entered through said ports, viz., on the Atlantic seaboard, the ports of Boston, New York. and Baltimore; on the Pacific seaboard, San Diego; along the boundary between the United States and Mexico, Brownsville, Paso Del Norte, Eagle Pass, Loredo, and Nogales;

and along the border or boundary line between the United States and British Columbia and Canada, through the custom ports in the collection districts of Aroostook and Bangor, Maine; Vermont, Vermont; Buffalo Creek, Niagara, Cape Vincent, Champlain, and Oswegatchie, New York; Detroit, Port Huron, and Superior, Michigan; Minnesota and Duluth, Minnesota; and Puget Sound, Washington.

(2) The word "animals," when used in these regulations, refers to and includes all or any of the following kinds: Neat cattle, sheep and other ruminants, and swine. The words "contagious diseases," when used in these regulations, includes and applies to all or any of the following diseases: Anthrax in cattle, sheep, goats, or swine; contagious pleuro-pneumonia in cattle; tuberculosis in cattle; foot-and-mouth disease in cattle, sheep, goats, and swine; rinderpest in cattle and sheep; sheep pox, foot rot, and scab in sheep; hog cholera and swine plague in swine.

(3) All cattle, sheep and other ruminants imported into the United States from any part of the world except North and South America shall be accompanied with a certificate from the local authority of the district in which said animals have been for one year next preceding the date of shipment, stating that no contagious pleuro-pneumonia, foot-and-mouth disease, or rinderpest has existed in said district for the past year. And all swine imported into the United States from any part of the world except North, Central, and South America shall be accompanied with a similar certificate relating to the existence of foot-and-mouth disease. All such animals shall also be accompanied with an affidavit by the owner from whom the importer has purchased them stating that said animals have been in the district where purchased for one year next preceding the date of sale, and that neither of the above mentioned diseases have existed among them, or among any animals of the kind with which they have come in contact, for one year last past, and that no inoculation has been practiced among said animals for the past two years. Also by an affidavit from the importer or his agent supervising the shipment stating that the animals have been shipped in clean and disinfected cars and vessels direct from the farm where purchased; that they have not passed through any district infected with contagious diseases affecting said kind of animals, and that they have not been exposed in any possible manner to the contagion of any of said contagious diseases.

(4) The foregoing certificate and affidavits must accompany said animals and be presented to the collector of customs at the ports of entry and by him be delivered to the inspector of the Bureau of Animal Industry stationed at said port to allow them to be imported into the United States.

(5) All neat cattle imported into the United States from any part of the world except North, Central, and South America shall be subject to a quarantine of ninety days, counting from date of arrival at the quarantine station. All sheep and other ruminants and swine from any part of the world except North, Central, and South America shall be subject to a quarantine of fifteen days, counting from date of arrival at the quarantine station.

(6) Any person contemplating the importation of animals from any part of the world except North, Central, and South America must first obtain from the Secretary of Agriculture two permits, one stating the number and kind of animals to be imported, the port and probable date of shipment, which will entitle them to clearance papers on presentation to the American consul at said port of shipment; the other, stating the port at which said animals are to be landed and quarantined, and the approximate date of their arrival, and this will assure the reception of the number and kind specified therein at the port and quarantine station named at the date prescribed for their arrival, or at any time during three weeks immediately following, after which the permit will be void. These permits shall in no case be available at any port other than the one mentioned therein. Permits must be in the name of the owner of or agent for any one lot of animals. When more persons than one own a lot of animals for which permits have been issued a release from quarantine will be given each owner for the number and kind he may own, and this release will be a certificate of fulfillment of quarantine regulations. Permits will be issued to quarantine at such ports as the importer may elect, so far as facilities exist at such port, but in no case will permits for importation at any port be granted in excess of the accommodations of the Government quarantine station at such port. Every importer shall, on the day of the shipment from a foreign port, telegraph to the Chief of the Bureau of Animal Industry the number and kind of animals shipped, the vessel on which they are shipped, and the port at which they are to be landed. United States consuls at foreign ports are hereby notified to give clearance papers or certificates for importation of animals only upon presentation of permits as above provided, with dates of probable arrival and destination corresponding with said permits, and in no case for a number in excess of that mentioned therein.

(7) All animals imported into the United States shall be carefully inspected by a veterinary inspector of the Bureau of Animal Industry, and all animals found to be free from disease and not to have been exposed to any contagious disease, except as provided in regulation 5, shall be admitted into the United States. Whenever any animal is found to be affected with a contagious disease, or to have been exposed to such disease, said animal, and all animals that have been in contact or exposed to said animal, will be placed in quarantine, and the inspector quarantining the same shall report at once to the Chief of the Bureau of Animal Industry, who will direct whether or not said animals quarantined shall be appraised and slaughtered, as provided by section 8, of the act under which these regulations are made. All animals quarantined by reason of disease or exposure to disease shall not be admitted to the established quarantine grounds, but shall be quarantined elsewhere, at the expense of the importer, or be dealt with in such manner as the Chief of the Bureau of Animal Industry shall determine.

(8) In case of imported animals proving to be infected, or to have been exposed to infection, such portions of the cargo of the vessel on which they have arrived as have been exposed to these animals or their emanations shall be subjected, under the direction of the inspector of the Bureau of Animal Industry, to disinfection in such manner as may be considered by said inspector necessary before it can be landed.

(9) No litter, fodder, or other aliment, nor any ropes, straps, chains, girths, blankets, poles, buckets, or other things used for or about the animals, and no manure shall be landed excepting under such regulations as the veterinary inspector shall provide.

(10) On moving animals from the ocean steamer to the quarantine grounds they shall not be unnecessarily passed over any highway, but must be placed on cars at the wharves or removed to the cars on a boat which is not used for conveying other animals. If such boat has carried animals within three months it must be first cleaned and then disinfected under the supervision of the inspector, and after the conveyance of the imported animals the boat must be disinfected in the same manner before it may be again used for the conveyance of animals. When passage upon or across the public highway is unavoidable in the transportation of animals from the place of landing to the quarantine grounds it must be under such careful supervision and restrictions as the veterinary inspector may, in special cases, direct.

(11) The banks and chutes used for loading and unloading imported animals shall be reserved for such cattle, or shall be cleansed and disinfected as above before being used for such imported cattle.

(12) The railway cars used in the transportation of animals to the quarantine grounds shall either be cars reserved for this exclusive use, or box cars not otherwise employed in the transportation of animals or their fresh products, and after each journey with animals to the quarantine grounds they shall be disinfected by thorough cleansing and disinfection under the direction of the veterinary inspector.

(13) While animals are arriving at the quarantine stations, or leaving them, all quarantined stock in the yards adjoining the alleyways through which they must pass shall be rigidly confined to their sheds. Animals arriving by the same ship may be quarantined together in one yard and shed, but those coming on different ships shall in all cases be placed in separate yards.

(14) The gates of all yards of quarantine stations shall be kept locked, except when cattle are entering or leaving quarantine.

(15) The attendants on animals in particular yards are forbidden to enter other yards and buildings, except such are occupied by stock of the same shipment with those under their special care. No dogs, cats, or other animals except those necessarily present shall be allowed in the quarantine grounds.

(16) The allotment of yards shall be under the direction of the veterinary inspector of the port, who shall keep a register of the animals entered, with description, name of owner, name of vessel in which imported, date of arrival and release, and other important particulars.

(17) The veterinary inspector shall see that water is regularly furnished to the stock and the manure removed daily, and that the prescribed rules of the station are enforced.

(18) Food and attendance must be provided by the owners of the stock quarantined. Employés of such owners shall keep the sheds and yards clean to the satisfaction of the veterinary inspector.

(19) "Smoking" is strictly forbidden within any quarantine inclosure.

(20) No visitor shall be admitted to the quarantine station without special written permission from the veterinary inspector. Butchers, cattle dealers, and their employés are especially excluded.

(21) No public sale shall be allowed within the quarantine grounds.

(22) The inspector shall, in his daily rounds, as far as possible, take the temperature of each animal, commencing with the herds that have been longest in quarantine and ending with the most recent arrivals, and shall record such temperatures on lists kept for the purpose. In passing from one herd to another he shall invariably wash his thermometer and hands in a weak solution (1 to 100) of carbolic acid.

(23) In case of the appearance of any disease that is diagnosed to be of a contagious nature the veterinary inspector shall notify the Chief of the Bureau of Animal Industry, who shall visit the station personally or send a veterinary inspector, and on the confirmation of the diagnosis the herd shall be disposed of according to the gravity of the affection.

(24) The yard and shed in which such disease shall have appeared shall be subject to a thorough disinfection. Litter and fodder shall be burned. Sheds, utensils, and other appliances shall be disinfected as the veterinary inspector may direct. The yards, fence, and manure box shall be freely sprinkled with a strong solution of chloride of lime. The flooring of the shed shall be lifted and the whole shall be left open to the air and unoccupied for three months.

(25) In the case of the appearance of any contagious disease the infected herd shall be rigidly confined to its shed, where disinfectants shall be freely used, and the attendants shall be forbidden all intercourse with the attendants in other yards, and with persons outside the quarantine grounds.

J. M. RUSK,
Secretary.

[The designation of the ports, named in the foregoing regulations as quarantine stations, was approved by the Secretary of the Treasury on the 16th day of October, 1890, as provided by section 8 of the act of Congress approved August 30, 1890, providing for inspection of meats and animals.]

It is believed that these regulations will not only protect our herds and flocks, but in view of the assurances to that effect received from the British authorities it will probably result in the revocation by the British Government of its regulation excluding American sheep from Great Britain.

The inspection and quarantine of all cattle, sheep, and swine imported into the United States will add largely to the work of this Bureau. During the twelve months ending June 30, 1890, cattle were imported to the number of 30,695 head and sheep to the number of 393,794. The figures of the Treasury Department fail to give the number of swine imported.

The increased duties levied under the present law may greatly diminish the number of animals imported into this country, although during the year just past 3,935 head of cattle and 16,303 head of sheep were admitted duty free on the ground that they were imported for breeding purposes.

INSPECTION OF SALTED MEATS FOR EXPORT.

The act of August 30, 1890, provides "that the Secretary of Agriculture may cause to be made a careful inspection of salted pork and bacon intended for exportation, with a view to determining whether the same is wholesome, sound, and fit for human food, whenever the laws, regulations, or orders of the government of any foreign country to which such pork or bacon is to be exported shall require inspection thereof relating to the importation thereof into such country, and also whenever any buyer, seller, or exporter of such meats intended for exportation shall request the inspection thereof."

This inspection has been assigned to the Bureau of Animal Industry and all arrangements have been made to carry the law into effect. It is too early at this writing to estimate the quantity of

meat that the Department will be called upon to inspect under this law, but should the prohibition now enforced by certain continental governments be removed so far as regards inspected meats, as there is now reason to hope, there is no doubt but that the amount will be very large. The regulations adopted for this inspection are as follows:

Regulations for the Inspection of Salted Pork and Bacon for Export.

UNITED STATES DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., September 12, 1890.

By virtue of the authority conferred upon the Department of Agriculture by section 1 of an act entitled "An act providing for the inspection of meats for exportation, prohibiting the importation of adulterated articles of food or drink, and authorizing the President to make proclamation in certain cases, and for other purposes," approved August 30, 1890, the following regulations for the inspection of salted pork or bacon for export, and the marks, stamps, or other devices for the identification of the same, are hereby prescribed:

(1) Whenever any foreign country, by its laws, regulations, or orders, requires the inspection of salted pork or bacon imported into such country from the United States, all packers or exporters desiring to export to said country shall make application to the Secretary of Agriculture for such inspection; also, whenever any buyer, seller, or exporter of such meats intended for exportation shall desire inspection thereof, he shall likewise make application to the Secretary of Agriculture for such inspection.

(2) The application must be in writing, and shall give the name of the packer of such meats, and, if the packer be the exporter, the probable amount of such meats to be exported per week or month for which inspection is requested; the name of the country, or countries, to which such meats are to be exported; the place at which inspection is desired and the date for such inspection. The applicant shall likewise agree to abide by these regulations, and to mark his packages as hereinafter provided.

(3) Every package containing salted pork or bacon which has been inspected must be branded or stenciled both on the side and on the top by the packer or exporter, as follows:

FOR EXPORT.

(*a*) (Here give the name of the packer.)
(*b*) (Here the location and State of the factory where packed.)
(*c*) (Here give the net weight of the salted pork or bacon contained in the package.)
(*d*) (If exported by other than packer, the name of the exporter.)
(*e*) (Name of consignee and point of destination.)

The letters and figures in the above brand shall be of the following dimensions: The letters in the words "for export" shall not be less than three-fourths of an inch in length and all the other letters and figures not less than one-half an inch in length. All letters and figures affixed to the top and sides shall be legible and shall be in such proportion and of such color as the meat inspector of the Department of Agriculture may designate.

(4) The meat inspector of the Department of Agriculture, having, after inspection, satisfied himself that the articles inspected are wholesome, sound, and fit for human food, shall affix to the top of said package a meat inspection stamp, to be furnished by the Department of Agriculture, said stamps bearing serial numbers, and the inspector will write on said stamp the date of inspection. The stamp must be securely affixed by paste and tacks, in such a way as to be easily read when the package is standing on its bottom. Not less than five tacks shall be driven through each stamp, one at each corner and one in the middle.

The stamp having been affixed it must be immediately canceled. For this purpose the inspector will use a stencil plate of brass or copper, in which will be cut five parallel waved lines long enough to extend beyond each side of the stamp on the wood of the package. At the top of said stencil will be cut the name of the inspector, and at the bottom of said stencil will be cut the district in which inspection is made. The imprinting from this plate must be with blacking or other durable material, over and across the stamp, and in such manner as not to deface the reading matter on the stamp; that is, so as not to daub and make it illegible.

The stamp having been affixed and canceled, it must immediately be covered with a coating of transparent varnish or other substance. Orders for stamps must be made by the inspector on the Chief of the Bureau of Animal Industry. The inspector having inspected and found wholesome the contents of said package and affixed the stamp thereon, will issue to the packer or exporter a certificate of inspection, reciting the time and place of inspection, the name of the packer, the name of the exporter, and the name of the consignee and country to which exported. He will also place on said certificate the number of the package. One certificate only will be issued for each consignment and must designate the stamp numbers of all the packages contained in said consignment.

(5) The inspector will enter in the stub of his stamp book the information given by the packer's brand on the package inspected, and will report daily on blank form (*m. i.* 1) the number of stamps issued on each date and all the information required by said blank.

(6) The certificates of inspection will be furnished by the Department of Agriculture and be issued in serial numbers and in triplicate form. The inspector will deliver one copy of said certificate to the consignor or shipper of such meat inspected, one copy he will attach to the invoice or shipping bill of such meat, and the third copy he will forward to the Chief of the Bureau of Animal Industry of the Department of Agriculture for filing therein. He will likewise make a daily report on blank form (*m. i.* 2) of all certificates issued on that date, and fill out said blank with all the information required thereon.

(7) Whenever the inspection of any salted pork or bacon is requested by an exporter or shipper at any other place than where packed, the packages containing such meats are to be opened and closed at the expense of the exporter, and said packages must be branded or stenciled in the same manner and contain the same information as prescribed in the case of inspection for a packer.

J. M. RUSK,
Secretary.

The new duties connected with this inspection of animals and meats, which have been assigned to this Bureau during the last year, will be seen by the above statement to be numerous and responsible. They involve a greatly increased amount of work, but their fulfillment will undoubtedly be of enormous benefit to the country, as they will insure the protection of our live stock from imported diseases and furnish a guaranty to foreign buyers that our meats are wholesome and that our export animals are free from the contamination of any communicable malady.

INVESTIGATION OF REPORTED DISEASES.

During the year the Bureau has been requested to investigate many cases of diseases supposed to be of a contagious nature, including a considerable number of cases of disease supposed by the owners of the animals to be contagious pleuro-pneumonia or foot-and-mouth disease. Careful investigation in every case showed that these suppositions were incorrect and that the affection was either an ordinary sporadic disease, or that it was tuberculosis or some other equally common disorder. There have been no cases of pleuro-pneumonia found except in a small district on Long Island and an equally small district in New Jersey, which has long been infected, but from which the contagion is now nearly or quite eradicated.

There have been several reports of foot-and-mouth disease in the interior of the country from persons who had never seen the European disease known by this name. Investigations have, however, shown in every case that the diagnosis was not justified by the facts, and that the actual disease was of a sporadic nature and not contagious. There has been no real foot-and-mouth disease in the United States since March, 1884, when it was introduced into the Portland quarantine station by cattle from Great Britain. The contagion in

this case was disseminated to a small extent outside the quarantine station, but it was immediately recognized and eradicated by prompt measures. With the three months' quarantine to which all bovine animals are subject, and the inspection of all other animals coming into the country, it is next to impossible to introduce foot-and-mouth disease without its being immediately recognized, and it would certainly be impossible for it to reach the interior of the United States without being discovered by the inspectors of the Department of Agriculture.

A recent circular issued by the State veterinarian of the State of Missouri, which was headed, "Foot-and-mouth disease," and which gave a somewhat detailed description of the symptoms of a disease which the State veterinarian thought might be the European foot-and-mouth disease, has excited considerable comment abroad and has been considered by some veterinary authorities as a demonstration of the existence of that disease; but careful investigation made by one of the inspectors of the Bureau demonstrated that the disease was not of a contagious nature, and that it had little, if any, resemblance to the foot-and-mouth disease of Europe. There had been no cattle or other animals taken to Missouri which had been imported from any country where foot-and-mouth disease exists, consequently there was no explanation of the appearance of a foreign contagion in that part of the country. Again, but one or two animals in a herd of twenty or thirty were affected, while with foot-and-mouth disease not one in a herd of that size would escape. In most cases there was little fever, the sores in the mouth were not of the nature of vesicles, and it is doubtful if any affected animals had any lesions about the feet which were the result of the disease. So small a proportion showed signs of lameness that this probably resulted in those animals from accidental causes.

There should be no difficulty in diagnosing at once such a disease as this as distinct from the foot-and-mouth disease of Europe. The foot-and-mouth disease could not originate spontaneously. It must have a point of origin by contagion which would connect the disease with the same malady in some other section of the world; again, foot-and-mouth disease is extremely contagious, being rapidly and unmistakably transmitted from animal to animal and from herd to herd. It attacks every animal in a herd, and not one animal in one hundred or even in a thousand exposed to the contagion escapes the disease, while the vesicles are prominent and unmistakable both in the mouth and about the feet. The increase in temperature and the fever are too marked to be overlooked. A disease with these characteristics has never existed in the interior of the United States. Rumors of such disease have been frequent, but they are started by people who are ignorant of the character of such diseases and who have had their imaginations excited by reading the accounts of these diseases in other countries.

Indeed, the reports are generally made in such a way as to show that the description of the disease is taken from some publication on the subject and not from the disease itself. This is the only possible explanation of the resemblance of the symptoms given in such reports to those observed in the disease suspected, for, when the disease itself is examined, such characters as they mention can not be found.

The report of the Bureau inspector, the main points of which were concurred in by the State veterinarian after a careful investigation, should be sufficient to remove any fears of the existence of this dis-

ease in the United States. Indeed the report of the existence of this disease would have attracted little attention had it not been for the great interests at stake and the evident desire of parties in other countries to find a pretext to sustain the restrictions and prohibitions now in force against the introduction of American cattle. These parties have always been ready to give credence to the wildest rumors and to put the worst construction upon any report in regard to disease in this country. The order that all American sheep and swine should be slaughtered on the English docks on account of foot-and-mouth disease, which has been enforced for the last ten years, and the unhesitating acceptance of the recent rumors of the same disease are sufficient evidence of the correctness of this statement. The United States Department of Agriculture now has a large and capable force of veterinary inspectors, whose whole time is devoted to the investigation of diseases, and the official reports of this Department are worthy of the same respect and credence as the government reports of any of the countries of Europe. Usually when a government makes an investigation of a rumored disease its report is believed without question. The numerous attempts which have been made to discredit the conclusion of this Department after the investigation of the disease in Missouri, without giving any adequate reason for not accepting it, show that these parties are influenced in regard to American questions by motives which do not apply to the same subjects when affecting other countries.

SCIENTIFIC INVESTIGATIONS.

The original scientific research of the year has been mostly confined to southern or Texas cattle fever and to the infectious diseases of swine. With both very important results have been obtained from the scientific as well as the practical point of view.

SOUTHERN OR TEXAS FEVER OF CATTLE.

The discovery of a germ in the red corpuscles of the blood in this disease—a germ entirely distinct from bacteria but belonging to the protozoa—was mentioned in the report of last year. This notable discovery was abundantly confirmed by the investigations of the year just past, and an additional point in the problem has been brought to light.

It has long been suspected by cattle owners that the appearance of the disease in northern cattle was in some way connected with the ticks distributed by southern cattle. This hypothesis has, however, been generally discredited by scientific men, and indeed the evidence in favor of it was very slight and intangible. It seemed, however, worthy of investigation, and the result has been to obtain indisputable evidence that the disease is produced by ticks from southern cattle.

Ticks taken from southern animals and placed upon pastures which could have been infected in no other way, so infected these grounds that susceptible cattle placed upon them contracted the disease in the same length of time and were as seriously affected as were other susceptible cattle placed upon pastures in company with southern cattle. Again, young ticks that were hatched from the eggs of large ticks picked from southern cattle were placed upon susceptible animals and produced the disease.

There are, consequently, two factors in the production of southern fever—first, the tick, and secondly, the protozoal microörganism which lives in and destroys the red blood corpuscles of the affected cattle. Where the tick obtains the protozoön is not yet known, but that the microörganism can be transmitted from one generation of ticks to another through the egg is demonstrated. It is important to learn through how many generations of ticks the germ can be transmitted without losing its virulence and whether there is any other means by which it gains access to the system of cattle in addition to being introduced by the punctures made by ticks.

There are evidently ticks which do not harbor this minute parasite, because cattle susceptible to southern fever are frequently badly infested with ticks without showing any marked symptoms of disturbed health. On the other hand there may be means by which the protozoön gains access to the blood of cattle independently of the agency of ticks; but it appears from the investigations just made that in the great majority of cases cattle are infected by means of ticks. That is, the adult ticks drop from southern cattle and lay their eggs upon the pastures. The eggs hatch and the young ticks get upon susceptible cattle and produce the disease.

If this supposition is correct it is of great practical importance. In the first place, susceptible cattle taken to the South for breeding purposes could be protected from the fever by keeping them in such a manner that they would not become infested by ticks. That is, they could be kept in stables not previously occupied by other cattle, bedded with clean straw and fed upon hay or grass cut from fields where no cattle had been for a considerable time. In the second place, it would seem that southern cattle might be rendered innocuous by washing them with some preparation that would destroy the ticks, or by holding them upon uninfected ground a sufficient time for the ticks which are upon them to mature and drop to the ground, but not long enough upon any one pasture for the young ticks to hatch and reinfect them.

The probability of reaching important practical results is such that these investigations should be continued until the subject is thoroughly understood.

SWINE DISEASES.

The investigations of swine diseases have been carried on with the idea of determining (1) the relative prevalence of hog cholera and swine plague, (2) the value of protective inoculation by various processes as a preventive of hog cholera, and (3) to test the practicability of preventing those diseases by the use of the ptomaines or bacterial products developed by growing the germs in proper culture media.

These researches have shown that swine plague is relatively more prevalent than was first anticipated and that it is probably the cause of as much mortality as is hog cholera. They also confirm our conclusion of last year that inoculation is not a practical or reliable method of preventing hog cholera.

The investigations of the bacterial products have been very interesting, at least from a scientific point of view and as regards their application to the prevention of human diseases. This interest is increased at the present time by the announcement of the celebrated German investigator, Professor Koch, that he has discovered a remedy for tuberculosis. This remedy is now believed to be a product

of the growth of the bacillus of tuberculosis in appropriate culture material.

It should not be forgotten that the possibility of applying these bacterial products to the prevention and cure of diseases was first made evident by the investigations of the Bureau of Animal Industry, and that if Professor Koch's remedy is of the nature supposed his method consists in the application of a principle discovered here.

Our recent work in this line has been to separate the substance which has this preventive power from the many other chemical principles present in the culture liquids, and to study its nature and properties. This chemical work was placed in the hands of Dr. von Schweinitz with general directions as to the character of the investigations, in the spring of 1890, and since that time the products of the hog-cholera germ have been studied quite thoroughly and their remarkable power in conferring immunity has been confirmed.

Unfortunately these products are very irritating, and in the dose necessary to produce an effect upon the system of the hog they cause an inflammation at the point where injected into the tissues, which is a great objection to their use. They could be given in smaller and more numerous doses, but this increases the expense so much as to make their use impracticable. When administered by way of the stomach their effect is lost.

That this method of preventing disease with other maladies and other species of animals and particularly with mankind is destined to be of much service seems very probable. With this ultimate object in view we have endeavored to produce artificially a drug which would have the same composition and effect as the bacterial products. By such a process we hope to obtain the preventive agent at less expense and without danger of being contaminated with the deadly germs that cause the disease. To a great extent these researches have been successful and we are now able to produce a substance entirely by chemical processes which not only resembles the bacterial product of the hog-cholera germ in composition but which has almost if not quite the same power of conferring immunity from the disease.

By these preliminary studies we have worked out the proper methods of investigation, and it is hoped that by applying them to tuberculosis and other diseases which affect animals of greater value than hogs successful means of prevention may be secured. And if incidentally these methods of prevention can be applied to diseases affecting mankind, their value to the country and to the world will only be increased thereby.

GLANDERS.

The improvement in the District of Columbia in regard to this disease is shown by the number of affected animals discovered in 1890 as compared with those in 1889. The last report of this Bureau gave the number of horses condemned each month up to and including November, 1889. Since then the number condemned monthly has been as follows:

December	0	July	4
January	2	August	1
February	2	September	2
March	0	October	2
April	4	November	0
May	2		—
June	4	Total	23

During the twelve preceding months the number condemned was seventy-eight. During the spring of 1890 a very general inspection was made through the city with especial attention to all large stables, and the fact that so few animals were discovered shows that now the District is very nearly free from the disease. It is impossible, of course, to maintain absolute freedom from such a malady, as it is frequently introduced by horses from other parts of the country that are sold in this market.

PUBLICATIONS.

The great need of publications for gratuitous distribution which treat in a systematic and thorough manner of the different subjects connected with the breeding and care of the domestic animals has long been apparent. The field is a large one to cover and can not be properly treated in the works of private firms without making the publications so expensive that they would be beyond the reach of the people who most need them. For this reason the Bureau of Animal Industry has undertaken the preparation of a series of reports on the breeding and management of live stock in health and disease.

These reports are intended for popular use, and while so complete and accurate that they will be useful to the professional man or scientist, their language is to be as plain and free from technicalities and unusual expressions as is consistent with a clear and forcible treatment of the subject. Their purpose is educational, and it is hoped that they will do much to clear away the absurd traditions and practices born of ignorance which still obtain in some parts of the country, and that they will furnish a basis for a progressive and successful management.

Large amounts of money are being expended for improved stock, and unless buyers understand the peculiar characters of the different breeds, the conditions under which they have been formed, the care which is necessary for their existence, and the diseases to which they are subject, they can only meet with indifferent success in breeding them. The best stock is the result of the most intelligent management, care, and selection, and unless this management and selection are continued the stock will deteriorate.

The number of breeders who have succeeded in establishing or improving a breed have been relatively few, and the number who can even maintain all the good qualities of our most improved breeds without continually infusing new blood are not numerous. This shows a lack of knowledge among the great majority of breeders as to the requirements of improved breeds of animals which calls for correction. It is the object of this Bureau to collect this valuable information from the few who do know and distribute it broadcast to the many who ought to know.

The first work of the series treats of the animal parasites of sheep, one of the most important subjects which confronts the sheep breeders. This work has been received with great favor, and the first edition was exhausted within a few months after it was ready for distribution. A second edition was immediately ordered and the applications for copies are still numerous.

The second report of the series is at this writing going through the press, and it will probably be ready for distribution by the 1st of February, 1891. It treats of the diseases and accidents from which

horses suffer, and it will be useful to an even larger class than the volume which has preceded it. No labor has been spared either on the text or the illustrations, and we have endeavored to make it compare favorably with the splendid volumes in other and less practical fields of science and research which the various departments of the Government have from time to time issued.

A volume on sheep husbandry and one on trotting and thoroughbred horses will be ready for the press almost as soon as the report just mentioned is out of the way. In addition to these the regular report of the Bureau of Animal Industry for the years 1888 and 1889 is in an advanced stage of preparation and will be sent to the press early in 1891.

CONDITIONS AFFECTING THE PRICE OF HOGS.

The conditions affecting the price of the animals produced upon the farm is one of the most interesting and important studies which can be made for the benefit of the stock grower, and as the chief of the Bureau has recently made an investigation of this subject a brief statement of the facts and conclusions are inserted in this report.

The fluctuations in the price of hogs appear at present to be more easily traced and more subject to principles that can be definitely formulated than the variations in the price of other farm animals, and consequently they have been selected for this preliminary investigation.

The calculations which follow are principally based upon the statistics of the United States Census Bureau, the estimates of the Statistical Division of the Department of Agriculture, the report of the Bureau of Statistics of the Treasury Department, and the annual report of the Cincinnati Price Current. The population for the intermediate years is estimated by the rate of growth for the ten years, taking account each year of the immigration.

The following table shows the population of the United States, the total hog product including lard put on the market by the packing establishments, the quantity which this constitutes per capita of population, the quantity of hog product exported, and the total and per capita quantity remaining for home consumption for each year since 1873:

TABLE 1.

Years.	Population.	Hog products.				
		Total.		Exported—year ending June 30.	Home consumption.	
		Pounds, year ending March 1.	Per capita.		Pounds.	Per capita.
1873	42,125,489	1,654,707,583	39.3	690,063,405	964,644,178	22.9
1874	43,281,338	1,701,314,614	39.3	623,415,255	1,077,899,359	24.9
1875	44,374,463	1,611,038,842	36.3	473,308,273	1,137,730,569	25.6
1876	45,431,938	1,457,743,118	32.1	550,331,129	907,411,989	20.0
1877	46,482,434	1,669,369,043	35.9	764,470,273	904,898,770	19.5
1878	47,550,552	2,045,239,979	43.0	1,007,371,526	1,037,868,453	21.8
1879	48,679,389	2,515,978,153	51.7	1,143,309,938	1,372,668,215	28.2
1880	50,155,783	2,423,535,672	48.3	1,230,702,175	1,192,833,497	23.8
1881	51,473,728	2,643,053,296	51.5	1,233,015,127	1,410,038,169	27.4
1882	52,928,275	2,357,932,478	44.5	798,841,846	1,559,090,632	29.5
1883	54,215,960	2,148,369,223	39.6	627,093,446	1,521,275,777	28.1
1884	55,435,564	2,228,427,478	40.2	715,142,817	1,513,284,661	27.3
1885	56,547,692	2,441,877,868	43.2	755,416,926	1,686,460,942	29.8
1886	57,613,057	2,586,117,826	44.9	800,784,530	1,785,333,296	31.0
1887	58,848,103	2,677,814,968	45.5	827,349,998	1,850,464,970	31.4
1888	60,155,898	2,523,552,000	42.0	732,079,843	1,791,472,157	29.8
1889	61,378,141	2,479,053,000	40.4	782,601,275	1,696,451,725	27.6
1890	62,622,250	3,047,651,000	48.7	1,159,642,885	1,888,008,115	30.1

The quantity of pork products put upon the markets by the packing houses of the East and West is partly estimated, but is so nearly correct that the exact figures could not in any way change the conclusions which are here drawn from the table.

We see by this table the enormous amount of hog product put upon the market in this country, an amount which varies in round numbers from 1,457 million pounds in 1876 to 3,047 million pounds in 1890. No account is taken of the hogs killed and consumed by farmers or sold in villages, towns, and cities, but which are not packed, as there are no definite data from which it can be determined. Although this quantity is large it probably has no great effect upon the price of hogs in the packing centers, since it is the visible supply of hog products, the quantity put into the channels of commerce by the packing establishments, which we would expect to influence prices.

As would be expected there has been a great increase of hog product during the years covered by the table. From 1873 to 1877 the total amount was less than 2,000 million pounds per annum, varying from 1,457 millions in 1876 to 1,701 millions in 1874. From 1878 to 1889 the product was over 2,000 millions each year, varying from 2,045 millions in 1878 to 2,677 millions in 1887, and reaching the enormous aggregate of 3,047 millions in 1890. The quantity which this constitutes per capita of population varies from 32.1 pounds in 1876 to 51.7 pounds in 1879 and is only 48.7 pounds for the great output of 1890.

The quantity of pork products exported reached the highest figures in 1880 and 1881, dropping off in 1882 and subsequently, as a result of the unfavorable restrictions and prohibitions imposed by several foreign governments. Deducting the exports from the total production we find that the quantity left on the domestic market for home consumption has varied from 19.5 pounds in 1877 to 31.4 pounds in 1887 and was 30.1 pounds in 1890.

In order to bring out the effect of demand and supply upon the price the following table has been compiled, which shows in parallel columns the cost of the hogs used for the winter packing in the West, the total hog product per capita, and the domestic supply per capita for the year:

TABLE 2.

Year.	Cost of hogs, winter packing to March 1.	Hog product, per capita.	Domestic supply per capita.	Year.	Cost of hogs, winter packing to March 1.	Hog product per capita.	Domestic supply per capita.
1873	$3.73	39.3	22.9	1882	$6.06	44.5	29.5
1874	4.34	39.8	24.9	1883	6.28	39.6	28.1
1875	6.66	36.3	25.6	1884	5.18	40.2	27.3
1876	7.05	32.1	20.0	1885	4.29	43.2	29.8
1877	5.74	35.9	19.5	1886	3.66	44.9	31.0
1878	3.99	43.0	21.8	1887	4.19	45.5	31.4
1879	2.85	51.7	28.2	1888	5.04	42.0	29.8
1880	4.18	48.3	23.8	1889	4.99	40.4	27.6
1881	4.64	51.3	27.4	1890	3.66	48.7	30.1

This table shows that in a general way the cost of hogs has varied inversely with the total hog product per capita, that is to say, the cost has increased in most cases as the product decreased, and *vice versa*. The variations are not always, however, in this inverse sense,

and there is even less correspondence to be found between the fluctuations in cost and the quantity remaining for domestic consumption per capita. It is evident that there is some influence aside from the mere question of supply and demand, which has had an equal or greater effect on the price of hogs. Our investigation indicates that this important factor is the price of corn.

The following table is compiled to show in parallel columns the value on the farms of the corn crop and the cost of hogs for the succeeding winter's packing:

TABLE 3.

Year.	Cost of corn on farms.	Year.	Cost of hogs, winter packing to March 1.
	Cents.		
1872	39.8	1872-'73	$3.73
1873	48.0	1873-'74	4.34
1874	64.7	1874-'75	6.66
1875	42.0	1875-'76	7.05
1876	37.0	1876-'77	5.74
1877	35.8	1877-'78	3.99
1878	31.8	1878-'79	2.85
1879	37.5	1879-'80	4.18
1880	39.6	1880-'81	4.64
1881	63.6	1881-'82	6.06
1882	48.4	1882-'83	6.28
1883	42.0	1883-'84	5.18
1884	35.7	1884-'85	4.29
1885	32.8	1885-'86	3.66
1886	36.6	1886-'87	4.19
1887	44.4	1887-'88	5.04
1888	34.1	1888-'89	4.99
1889	28.3	1889-'90	3.66

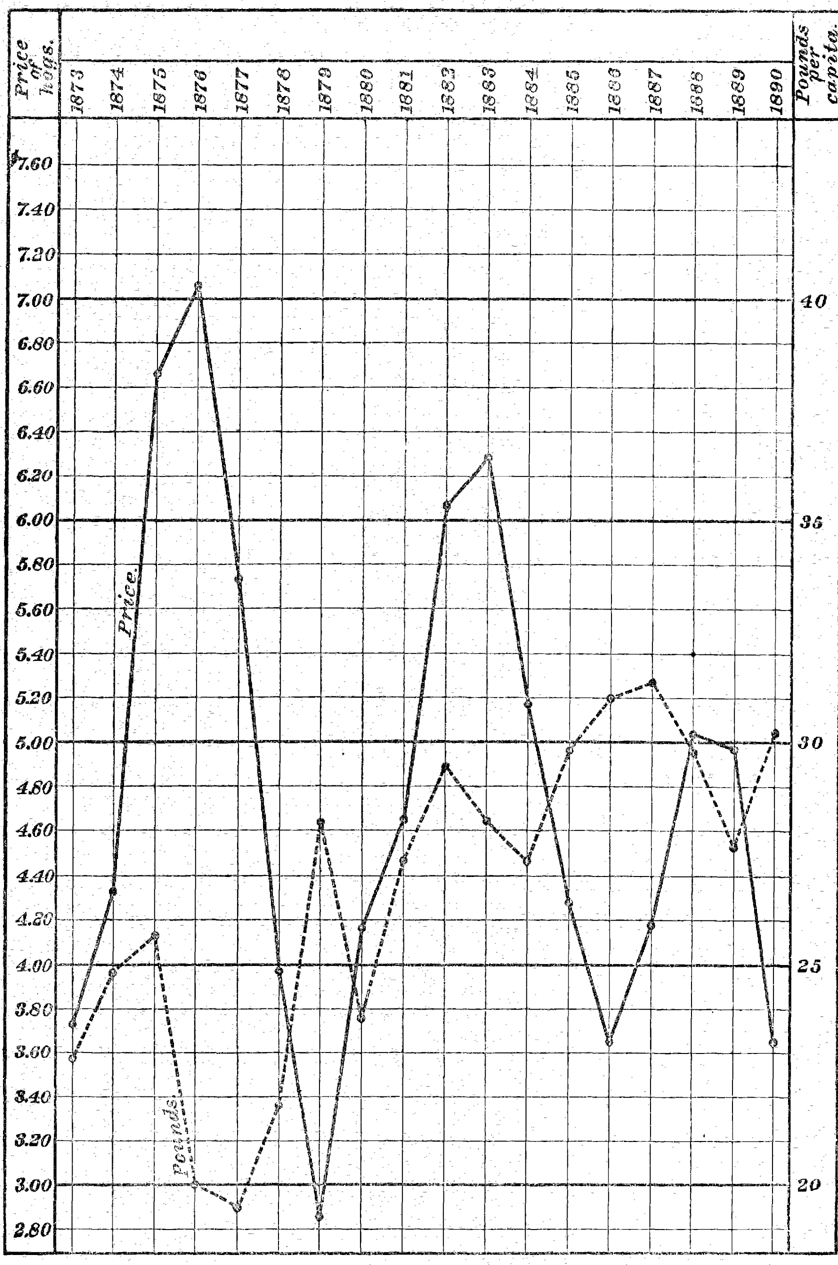
The above table shows that the fluctuations in the price of corn and of hogs correspond so closely as to be really surprising. The only discrepancies are in accordance with what appears to be a general rule that there is a tendency, after corn has been high, for the price of hogs to be sustained or even to advance for one year after corn has declined.

These facts are best shown by the accompanying diagrams. The domestic supply of hog product per capita, that is, the total hog product put on the market by the packing houses less the quantity exported, is compared in Diagram A with the price paid by packers in the West for hogs used in the winter's packing. It will be seen that while the direction of the lines representing the fluctuations is generally in an opposite direction, this relation is by no means constant. It is evident that there are other and more important factors which influence the price of hogs.

Diagram B illustrates the fluctuations in the price of corn, the price of hogs, and the total hog product per capita placed upon the markets by the packers. By following the direction of the lines from year to year it is seen that there was a sharp advance in the price of the corn crops of 1873 and 1874, the price of hogs immediately following. The decline in the price of corn in 1875 was not at once followed by a decline in the price of hogs, but, on the contrary, the winter packing ending March 1, 1876, cost more than that of 1875, although made from cheaper corn. The reason for this is seen in the decline in production. In 1879, 1880, and 1881 we find another advance in corn, followed at once by an advance in hogs. Again we find the

DIAGRAM A.

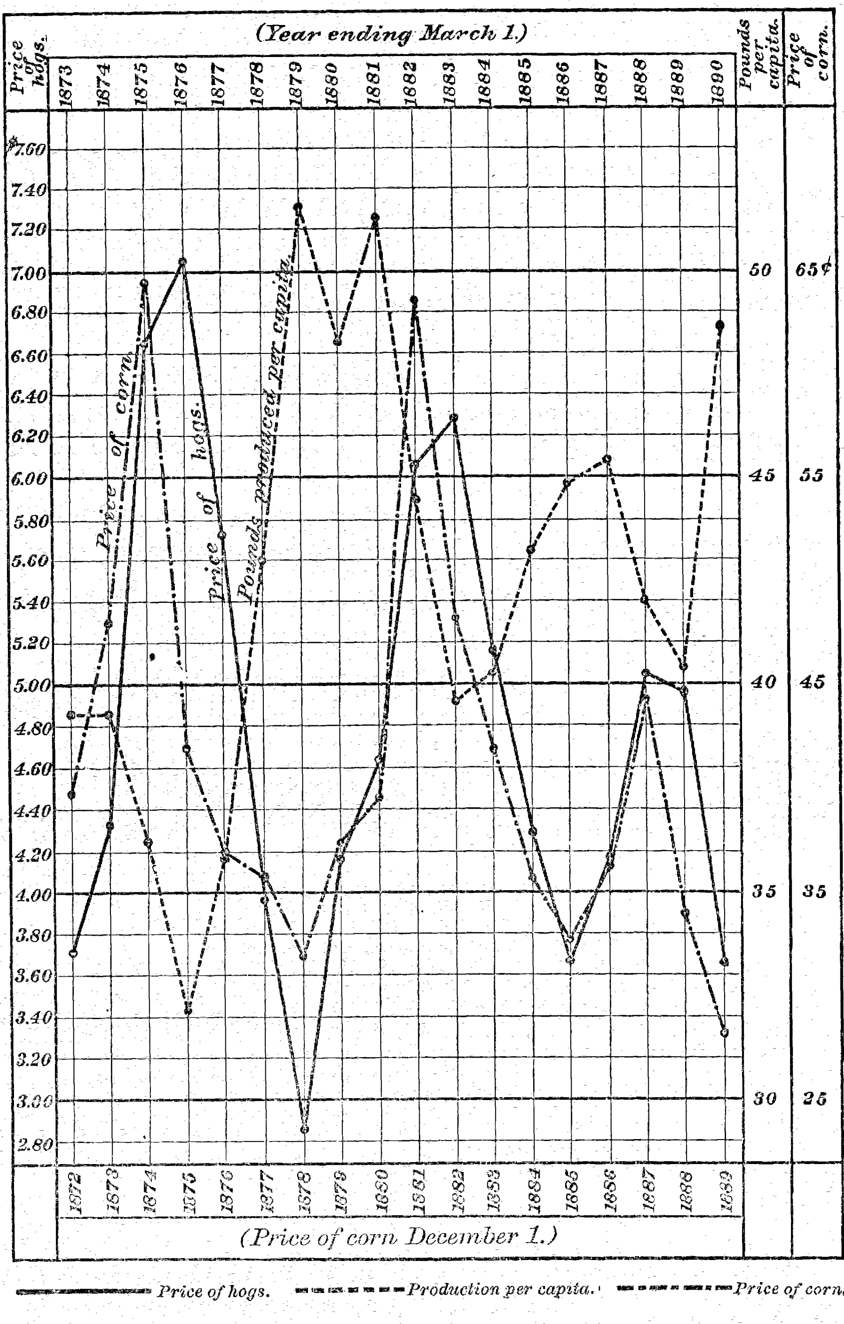
Average price of hogs and home consumption of hog products per capita.



Price of hogs. Consumption per capita.

DIAGRAM B.

Average price of hogs, compared with the total production of hog products per capita, and the price of corn.



price of hogs advancing in the winter of 1882–'83, although the 1882 corn crop shows a very considerable decline in price. This advance in the price of hogs corresponds with a decreased production of hog product per capita of population. The second year of decline in the price of corn, that is, 1883, is followed by a marked decline in the price of hogs, and this corresponds with a slight increase in production of pork product. Then we find that, with the continued decline in corn during 1884 and 1885, there was also a decline in hogs. The 1886 corn crop brought more money and the price of hogs at once advanced. The crop of 1887 was still higher in price and the price of hogs again advanced. The 1888 corn crop was lower in price, and here we see the effect of the rule above referred to, for, while the price of hogs did not advance, it was sustained and the drop was very slight, only 5 cents per hundred pounds. In 1889 the price of corn was still lower and the drop in the price of hogs was very marked.

If, now, we turn our attention to the line on the chart showing the quantity of hog product in proportion to the population we find that in 1874 the price of hogs advanced before there was any decrease in production. The second year after the advance in corn the reduction in the quantity of hog product is marked, and the reduction continued one year after there was a fall in the price of corn. In 1878–'79 the production per capita reached the highest point, corresponding with the low-priced corn crop of 1878. In 1880 there was a decrease in hog product corresponding to the advance in corn, and in 1881 we find an exception to the rule—an increase in hog product and at the same time a second increase in price of corn. Then comes a drop in production in 1882 corresponding to the increase in the price of the corn crop of 1881. With the drop in the price of corn in 1882 we find that the hog product instead of increasing continued to decrease. This shows a tendency, exhibited also in 1876, that should be noted, which is that the hog product does not always respond to a fluctuation in the price of corn until the succeeding year. That is, when the hog crop has been decreasing for one or more years it requires some time to change the conditions and increase it, or *vice versa*. We see the operation of this rule again in the increase in the product of 1887 over 1886, although there was an advance in the price of the crop fed. So again the decrease in the price of corn in 1888 over 1887 was not followed by an increase in hog production until the succeeding year.

From these facts we may conclude that during the eighteen years covered by the tables and charts the following general rules appear to bear upon this question:

(1) The price of hogs increased with the price of corn without regard to the amount of hog product placed upon the market.

(2) After an advance in the prices of corn and hogs for a series of years the price of corn dropped one year before the decline came in the price of hogs.

(3) The fluctuation in the quantity of hog product per capita of population which followed an advance or decline in the price of corn after having moved in the opposite direction did not usually occur until a year had intervened. When corn had been high this failure of the hog product to increase with the first decline in corn kept up the price of hogs or even increased it for one year after corn dropped; but when corn had been low the failure of the hog product to decrease in quantity the first year that corn advanced did not prevent the

advance in the price of hogs immediately following the increase in the price of corn.

It would appear that the above conclusions are worth remembering, for if these rules have held good for eighteen years they will likely apply for some time in the future.

Having determined some of the factors which have influenced the price of hogs, and having found that the most important of all was the price of corn, it may be well to briefly consider the causes which fix the latter. The following table shows the price of corn, the total production, and the production per capita of population.

TABLE 4.

Year.	Price of corn.	Production per capita.	Total production.	Year.	Price of corn.	Production per capita.	Total production.
	Cents.	*Bushels.*	*Bushels.*		*Cents.*	*Bushels.*	*Bushels.*
1873	48.0	22.1	932,274,000	1882	48.4	30.6	1,617,025,100
1874	67.7	19.6	850,148,500	1883	42.0	28.6	1,551,066,895
1875	42.0	29.8	1,321,069,000	1884	35.7	32.4	1,795,528,000
1876	37.0	28.2	1,283,827,500	1885	32.8	34.2	1,936,176,000
1877	35.8	28.8	1,342,558,000	1886	36.6	28.9	1,665,441,000
1878	31.8	29.2	1,388,218,750	1887	44.4	24.7	1,456,161,000
1879	37.5	36.0	*1,754,591,676	1888	34.1	33.0	1,987,790,000
1880	39.6	34.2	1,717,434,543	1889	28.3	34.4	2,112,892,000
1881	63.6	23.2	1,194,916,000				

* Census.

Diagram C illustrates these fluctuations graphically. We see that, beginning with 1872, there was a decreased production of corn per capita of population in 1873, and a further decrease in 1874, and that there was a corresponding increase in price. In 1875 there was an increase in production and a decrease in price. In 1876 there was a decrease in production and a further decrease in price. In 1877 there was a slight increase in production and an equally slight decrease in price. In 1878 there was another increase in production and a decrease in price. In 1879 there was a considerable increase in production and also an increase in price. In 1880 there was a slight decrease in production and a slight increase in price. In 1881 there was a great decrease in production and an equally marked increase in price. In 1882 the production increased and the price decreased. In 1883 there was a decrease both in production and price. In 1884 and 1885 the production increased and the price decreased. In 1886 and 1887 the production decreased and the price increased. In 1888 and 1889 the production increased and the price decreased. This shows that as a rule the increase in production corresponds with the decrease in price, and *vice versa*, the only exceptions being found in the years 1876, 1879, and 1883, or three years in the eighteen covered by the diagram.

It is interesting to note concerning the three exceptional years just mentioned that two of them, 1876 and 1883, correspond to the years on Diagram B, where it is shown that the price of hogs advanced in spite of the fact that the price of corn declined. That is to say, the reduction of the stock of hogs not only increased the price of hogs but lowered the price of corn, because there were not so many hogs to feed and the corn which would otherwise have been fed was put upon the market. The remaining exception, 1879, which is a fluctuation in the opposite direction, corresponds to the year on

DIAGRAM C.

Production of Corn per capita, and the average price per bushel on farms, December 1.

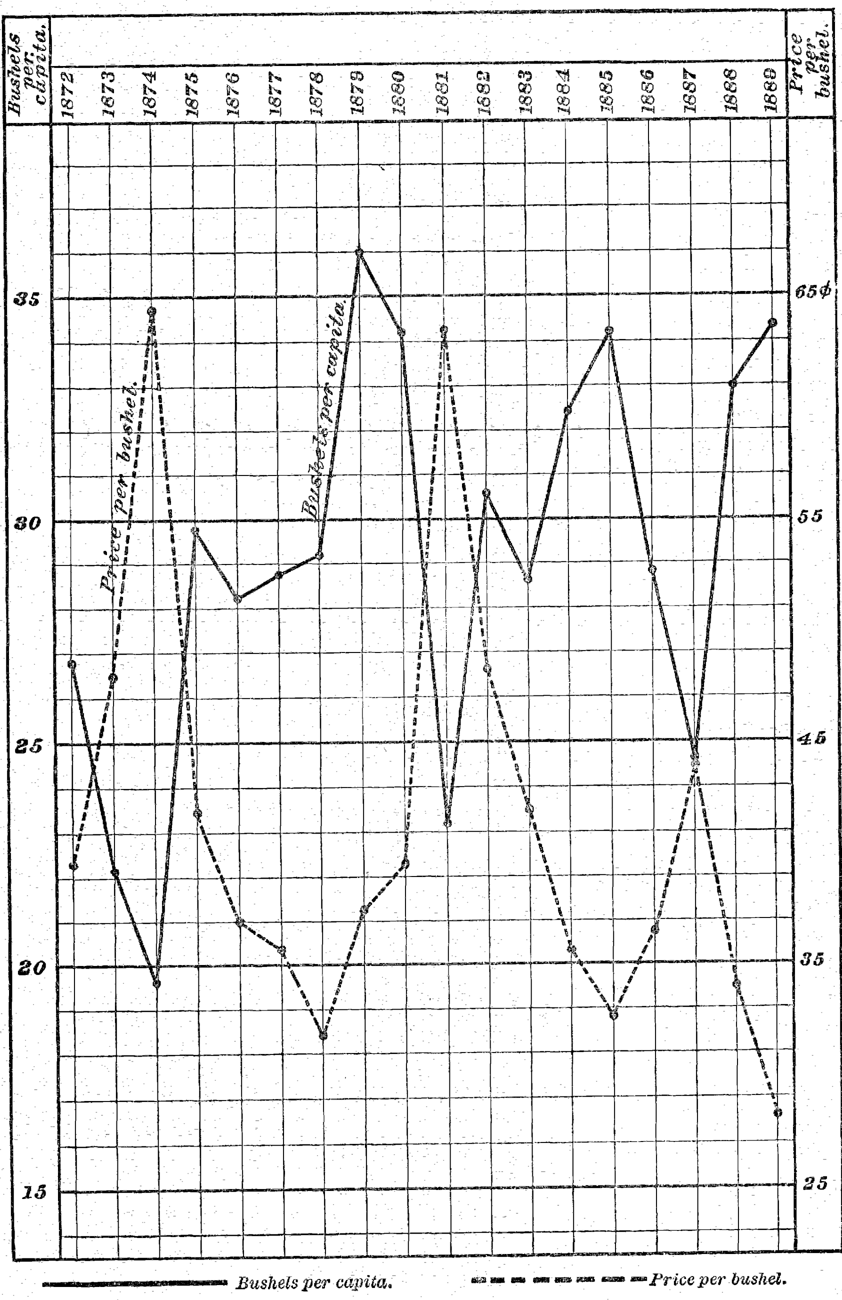


Diagram B when the production, and, consequently, the stock of hogs had reached the highest point. The large stock of hogs then on hand evidently was the means of furnishing a home market for the corn and caused an advance in price when under other conditions there would have been a further decline.

The price of corn is therefore governed primarily by the law of supply and demand, but it may also be influenced by the financial condition of the country, the purchasing power of money, and the relative supply of other cereals, and perhaps by other conditions.

There is one other point deserving of consideration in this connection. It is a very common custom when corn advances in price for farmers to hurry their hogs to market and reduce their breeding stock. A glance at the table demonstrates the existence of this custom, for we see that the hog product was invariably decreased as the price of corn advanced and when the price of corn declined the hog product again increased.

This fact has led the writer to inquire if there was in reality any less return to the feeder for each bushel of corn when the price was high than when it was low. To determine this the three years 1874, 1881, and 1887, were taken, at which the ascending lines were at their highest point, and it was found that the average price of corn for those years was 57.5 cents and the average price of hogs \$5.92—that is, the value of a bushel of corn was equivalent to the value of 9.54 pounds of hogs.

Taking now the four years 1872, 1878, 1885, and 1889, when the descending lines reached their lowest point, we find the average price of corn to have been 33.2 cents and the average price of hogs \$3.47. In this case a bushel of corn is equal in value to 9.56 pounds of hogs, or practically the ratio is exactly the same as when corn was high.

It appears that the best returns for hogs in comparison with the price of corn were received during the intermediate years between the extremely high or extremely low prices. Taking the eight years 1873, 1876, 1877, 1879, 1880, 1883, 1884, and 1886, we find the average price of corn to have been 39 cents and the average price of hogs \$4.59. For these years it will be seen that 8.5 pounds of hogs brought as much as a bushel of corn.

These facts are important as indicating the proper course for the farmer to pursue under the varying conditions which are here considered. Their application is so plain to those that are interested that it is not necessary to go into greater details in this report.

UNITED STATES CATTLE QUARANTINE.

The superintendents of the various neat cattle quarantine stations report the names of the importers and the number and breed of each lot of animals imported during the year 1890, as follows:

Station for the port of Baltimore, St. Denis, Maryland.

[Dr. A. M. Farrington, acting veterinary inspector.]

Date of arrival.	Name and post office address of importer.	Port of shipment.	Name of breed.	No. of animals.
1890. Mar. 17	S. C. Kent, West Grove, Pa	Liverpool	Guernsey	62

Station for the port of New York, Garfield, New Jersey.

[Dr. Wm. Herbert Lowe, superintendent.]

Date of arrival.	Name and post office address of importer.	Port of shipment.	Name of breed.	No. of animals.
May 13	H. N. Heffner, Delaware, Ohio	London	Red Polled	14
15	Alfred Sully, New York City	...do	Hereford	6
21	E. M. Barton, Hinsdale, Ill	Antwerp	Swiss	14
Nov. 27	W. W. Law, New York City	London	Jersey	4
	Total			38

Station for the port of Boston, Littleton, Massachusetts.

[Dr. A. H. Rose, superintendent.]

Mar. 21	R. J. Mendenhall, Minneapolis, Minn	Liverpool	Shorthorn	7
May 2	S. P. Clarke, Dover, Ill	...do	Galloway	2
July 3	...do	...do	...do	3
	Total			12

Station for the port of Boston, Littleton, Massachusetts.

[Dr. A. H. Rose, Superintendent.]

SHEEP.

Oct. 28	Jno. Milton, Marshall, Mich.	Liverpool	Shropshire	41

The following shows the whole number of cattle and sheep received at the various stations from January 1, 1889, to January 1, 1890:

Patapsco station	62
Garfield station	38
Littleton, Massachusetts	53
	153

INVESTIGATIONS OF THE INFECTIOUS DISEASES OF ANIMALS.

By Dr. THEOBALD SMITH.

The following brief account of the investigations conducted under my direction into the nature of the infectious diseases of animals has been prepared by Dr. Theobald Smith, who is in charge of this branch of the work of the Bureau of Animal Industry. All minor details, as well as the greater part of the autopsy notes, have been reserved for special reports, and only the most important results are given in this place.

INVESTIGATIONS OF TEXAS CATTLE FEVER.

The investigations into the nature and causes of Texas or southern cattle fever have been busily pushed during the summer of 1890, and some very important advances made which are destined to be of great practical importance.

During the summer of 1888 much time was spent in determining

whether or not any specific bacteria are the cause of this disease as they are of a host of human and animal infectious diseases. This was the more necessary inasmuch as former observers have always described bacteria of one kind or another associated with it. But no bacteria could be found in the bodies of animals which had succumbed to Texas fever excepting those which quite invariably multiply in dead bodies after a time and have no significance whatever. At the same time the writer came to the conclusion that the disease was confined to the blood and consisted essentially in a breaking down of the red corpuscles.

During the summer of 1889 arrangements were made by which the disease could be studied near the laboratory in Washington, and, as reported last year, a parasite was found within the red corpuscles whose presence could only mean the breaking up of the corpuscle itself sooner or later. This discovery was adapted to explain satisfactorily the various lesions observed, as well as the great reduction in the number of corpuscles observed in those cases which died after prolonged disease or which ultimately survived. In some of these cases the blood is watery; it has in fact scarcely any color remaining. This condition was expressed mathematically by counting the number of blood corpuscles. Thus in most cases before death the number of corpuscles was but one-sixth of the number normally present in the body. When we contemplate the very important functions of these elements we need not be surprised at the serious effects resulting from loss to the body, within one or two weeks, of five-sixths of its corpuscles.

During the present year the disease was produced at the Experiment Station by the importation of North Carolina and Texas cattle and the investigations continued. The work was sufficiently extensive to occupy most of the time from July to December, while the examination of preparations and other work connected with this subject occupied much of the writer's time last winter and will of necessity require much additional labor this winter.

During the summer about fifty-three native animals, distributed around in various experimental inclosures at the station, received more or less careful attention. The temperature of all was taken every other day by Dr. Kilborne to detect the beginning of the disease. Of these about twenty-four either succumbed to Texas fever or else were killed in a dying condition. These cases were subjected to a careful *post-mortem* examination, and the internal organs underwent a careful microscopic scrutiny at the laboratory. The surviving animals were examined at different intervals of time more especially with reference to the condition of the blood. The blood corpuscles were counted and carefully examined with reference to the presence of the Texas fever parasites in order to determine the presence of any disease and the progress it was making. Those animals that died were also examined more or less frequently during the course of the disease in the same way. It was found moreover that these blood examinations were absolutely necessary in many cases to detect any disease whatever, and they put the field experiments, to be outlined later on, on a positive basis.

The examination of the internal organs, such as the spleen, liver, and kidneys, from those animals that died of Texas fever showed the presence of the blood parasite described last year in every case; in some in such enormous numbers that every other blood corpuscle appeared infected. In the course of the disease the parasites were

detected in many of the cases examined. They were also present in the circulating blood one or two days before the animal died.

This parasite, which, as has been stated before, does not belong to the bacteria but to the protozoa, received considerable attention during the summer. It has appeared under several forms, and distinct amœboid movements of the largest forms were seen within the red corpuscles whenever the preparation was maintained above a certain temperature.

The work of the summer has thus confirmed that done during the two previous summers. There can be no doubt of the existence of genuine parasites within the red corpuscles and their destructive activity.

THE RELATION OF TICKS TO TEXAS CATTLE FEVER.

While the investigations into the nature of this disease were going on other equally important work was being carried on at the Experiment Station on the external characters of the disease.

It is well known to those who have come in contact with southern cattle in summer that they are infested with the so-called cattle-tick, a pest belonging to the class *Arachnoidea* and to the family *Ixodidæ*. These ticks are carried north with cattle during the warm season of the year. When fully matured they drop off from the southern animals, lay their eggs on the ground, and perish. The young ticks are hatched within fifteen to thirty days after the eggs are laid and at once get upon the cattle where they become mature within twenty to thirty days to again drop off, lay their eggs, and die. This process goes on continuously until the cold weather comes.

At various times and in different parts of the country it has been suggested that the ticks were the cause of Texas fever in northern cattle. This inference was undoubtedly suggested by the fact that nearly all cattle that die of Texas fever are observed to have these ticks of various sizes attached to the skin. Moreover the disease only makes its appearance after the young ticks have attached themselves to cattle. Though this was purely a *post hoc propter hoc* inference, it was nevertheless true, as the experiments to be recorded will amply prove.

During the summer of 1889 Dr. F. L. Kilborne, in arranging the various inclosures at the Experiment Station for the exposure of native cattle to the infection of Texas fever, conceived the happy idea of testing this popular theory of the relation of ticks to the disease. This he did by placing southern (North Carolina) cattle with native cattle in the same inclosure and picking the ticks from the southern stock as soon as they had grown large enough to be detected on the skin. This prevented any ticks from maturing and infecting the pasture with the eggs and hence prevented any ticks from infesting native cattle subsequently. At the same time, in another inclosure, the ticks were left on the southern cattle. The natives in the latter field died of Texas fever; those in the former did not show any signs of the disease.

Another experiment was made in September in the same manner by preparing three fields, one with southern cattle and ticks, a second with southern cattle from which the ticks were removed, and a third over which only adult ticks had been scattered. The result was equally positive. In the first field no natives died, but careful examination of the blood by the writer showed Texas fever in an un-

mistakable manner. In the "tick" field one animal died of Texas fever, and the examination of the blood showed that most other natives in the field were sick. In the third field containing southern cattle without ticks no disease could be detected.

These two tests pointed directly to ticks as being in some way the cause of Texas fever. At the same time it was thought best to confirm these results by further experiments during the present year before other agencies could be eliminated. The immediate inference was that the ticks infect the pastures, and that in some unexplained manner the infection finds its way into the body of susceptible cattle. The preliminary conclusions deducible from the work of 1888 and 1889 can be formulated as follows:

(1) Texas fever is a disease not caused by bacteria. Its nature can not be understood by supposing a simple transfer of bacteria from southern cattle to pastures and from pastures to northern cattle.

(2) The cause is very probably a protozoön, with a more complex life history, living for a time within the red corpuscles of infected animals.

(3) Southern cattle without ticks can not infect a pasture.

(4) Ticks alone scattered on a pasture will produce the disease.

The work of 1890 was planned to confirm or refute these preliminary conclusions and to furnish additional information.

The fields were arranged as before. One contained North Carolina cattle with ticks, a second Texas cattle with ticks, a third North Carolina cattle without ticks, a fourth ticks only, and a fifth soil from the pastures of infected North Carolina farms. Other fields were also laid out to test questions which need not engage our attention in this brief survey.

The results confirmed those of last year. The first animal to die was in the "tick" field, containing no southern cattle. No disease appeared in the soil field. Unfortunately, owing to the limited space of ground at our disposal and its barren, rolling character, ticks or eggs were washed during the very heavy rains of the summer from the tick field into the field containing southern cattle without ticks, although a wide lane intervened. The natives in this field thereupon all died of Texas fever. At the autopsy of these cases ticks were found attached to their skin in abundance.

The disease caused by Texas cattle could not be distinguished in character from that which was produced by North Carolina cattle. These results similarly pointed to ticks as the cause. The precise manner in which they caused the disease was by no means clear, however. The theory which seemed for a time most acceptable was that the adult ticks as they dropped off infected the pastures with germs which they had taken in with the blood of southern cattle, and that the germs were introduced into the body of northern cattle with the food. At the same time no parasite could be detected in the blood of southern cattle examined at various times, on which fact I would lay no great stress, however. Of more importance is the peculiarity which is exhibited by this disease in its period of incubation, as it may be provisionally denominated, and which is opposed to this theory. Thus, when native and southern cattle are placed on the same pasture at the same time it will take from forty to sixty days for the disease to appear. After the disease has once shown itself fresh animals placed on the same pasture may die, according to our experience, within thirteen days after the begin-

ning of the exposure. We might say that the virus has "to ripen" on the pasture, which takes nearly two months, depending on meteorological conditions. When once "ripened" this virus does its deadly work within two or three weeks. This explanation, however, would be merely formulating our ignorance concerning the true nature of the infectious principle.

To the writer there seemed but one inference to be drawn from the facts and that is that the presence of young ticks is in some way directly associated with the appearance of the disease. It requires from forty to sixty days for the matured ticks to drop from the southern cattle and the eggs laid by them to develop into young ticks. After that period young ticks are present on the pastures until they are destroyed by the cold, or until the cold interferes with the development of the embryo in the egg. In other words, the period of incubation of the disease is explained without any difficulty by the life history of the tick.

The question was solved, experimentally, in the following manner: Eggs laid by ticks sent from North Carolina were placed on dried leaves in a dish partly filled with moist soil and kept in the laboratory until the young emerged from the egg. The period of incubation depends entirely upon the relative amount of heat, and has varied from fifteen days in midsummer to forty days in November, when the rooms of the laboratory became cold at night (50° to 60° F.). These ticks were placed on four different animals of different ages, kept away from any infected inclosures. Two were placed in stalls, one of them on an adjoining farm, and two were allowed to stay in a patch of woodland with healthy cattle. Of these four two died of Texas fever, as determined by careful *post-mortem* examination. One of them was in the stall away from the Station, the other in the patch of woodland. The other two became very ill; one of them never recovered but had to be killed later on, the other recovered. In all of them the germs were observed in the blood. The disease possessed the same characters as those observed in cattle in the infected pastures during the summer. There was an elevation of temperature from nine to twelve days after the young ticks were placed on the animals, going as high as 107° F. in one animal. Accompanying the fever a gradual reduction in the number of blood corpuscles was observed. In order to show more conclusively the truth of the statements made a few brief notes from one of the experimental cases is appended:

No. 144.—Cow about eight years old, purchased September 16 from a neighboring farm and placed among a number of healthy reserve cattle in a piece of woodland at some distance from any infected field.

September 17.—A considerable number of young ticks, hatched in the laboratory from the eggs laid by ticks sent from North Carolina, placed on this animal.

September 18.—Temperature 101.2° F., 6.3 millions red corpuscles in blood; normal.

September 24.—Another lot of recently hatched ticks placed on the animal.

September 27.—A. M., temperature 104° F.

September 29.—10.45 a. m., temperature 106.2°, pulse 54, respirations 27, 4.93 millions corpuscles in blood. Ticks abundant on body, especially on inside of thighs. Still quite small.

September 30.—P. M., 107°.

October 1.—P. M., 106.3°.

October 2.—P. M., 104°.

October 3.—Found dead this morning. Seen alive at 6 p. m. yesterday. A large number of ticks on animal, just through second molt. None of them large as yet. Lungs only partly collapsed; trachea and bronchi filled with foam. Ecchymo-

ses under epicardium of both ventricles of heart and under endocardium of left ventricle.

Spleen very large, blackish, soft. Weighs 4 1-16 pounds. (Normal weight about 2 pounds.)

Liver weighs about 12 pounds; enlarged, yellowish on section. Complete injection of the intra-lobular bile capillaries. Extensive fatty degeneration of liver tissue. Occasional groups of hæmatoidin crystals.

Bile dark, scarcely flows. Density due to large quantity of yellowish flakes and mucus.

Kidneys deeply congested; tubules contain much yellowish pigment. Urine in bladder of a deep, port wine color, barely translucent in small test-tube; alkaline; specific gravity, 1015; no sediment; albuminous precipitate very abundant (.6 per cent. according to Esbach). Heavy flocculent precipitate when acetic acid added (hæmoglobin).

In preparations of blood from the heart, of liver, spleen, and kidneys a small number of corpuscles contain parasites, in contracted state, from 1.5 to 2 micro-millimeters in diameter. In the blood, spleen, liver, and kidney preparations a moderate number of large bacilli of *post-mortem* growth. (These bacilli are invariably present when the animal dies early in the night and is not examined until next day. They are never found in animals killed in a dying condition. They occur in other diseases under similar conditions.)

These brief notes demonstrate that Texas fever can be produced by placing young ticks on cattle, and that the disease can not be due to any abstraction of blood, for the ticks were still quite small and had scarcely begun to draw blood on a large scale. Moreover the corpuscles perished *in the body* as is shown by the coloring matter in the urine, by the thick bile, and the presence of pigment in the liver and kidneys. No disease appeared among the other cattle in the same inclosure.

While the nature of Texas fever is by no means made clear as yet, we are able to affirm that ticks can produce it. Whether the disease can be transmitted by any other agency must be decided by future investigations. Meanwhile the evidence accumulated thus far seems to favor very strongly the dictum: No ticks, no Texas fever.

SWINE DISEASES.

AN EXPERIMENT TO TEST THE VALUE OF SUBCUTANEOUS INJECTIONS OF HOG CHOLERA BACILLI AS A MEANS OF PREVENTING HOG CHOLERA.

In the report for 1889, page 87, it was stated that an experiment was in progress which we hoped would be a final test as to the practical value of subcutaneous injections of cultures of hog cholera bacilli in making swine insusceptible to the virus of hog cholera. The first tests in this direction were made at the Experiment Station early in 1886, soon after the hog cholera bacillus had been discovered. The tests at that time consisted in making two injections under the skin of minute quantities of culture liquid containing hog cholera bacilli, several weeks apart. This method was modeled after that of Pasteur in anthrax vaccination. No favorable result could de detected at that time. Although there was little hope that such a method would prove efficacious in another trial, still it was thought best to make it inasmuch as the disease to which the inoculated swine had been exposed in 1886 was of more than the usual virulence.

The method of subcutaneous injections of culture liquids containing hog cholera bacilli while on the one hand fraught with the possible danger of scattering disease germs where they do not origi-

nally exist is nevertheless the simplest and cheapest method that can be devised for the vaccination of animals; these qualities of simplicity and cheapness are of vital importance in a question which has only a commercial aspect. It was therefore thought best to give this method another and final trial, and in planning such an experiment it was considered necessary to eliminate all those sources of error which might possibly lead to an erroneous interpretation of results. Hence the following inportant conditions were kept in view:

(1) The animals must be young, unexposed hitherto even to a suspicion of disease. (2) There must be a large number of control or check animals of the same age and breed, which are to be subsequently exposed to the disease under precisely the same conditions as the vaccinated animals. (3) The disease to which they are exposed must have been carefully studied, the absence of other infectious diseases, such as swine plague, determined, and the virulence of the hog cholera germs causing it tested on rabbits. The disease must be virulent enough to prove fatal to the control animals to make the test of any value whatever.

That all these conditions are of prime importance is evident from general considerations, and was made evident in a very striking manner by the outcome of the experiment as will be seen further on.

The vaccine used.—In order to obviate the fatal effect of doses of hog cholera cultures injected under the skin which sometimes shows itself quite unexpectedly, especially in young animals, the writer deemed it advisable to reduce the virulence of the cultures by appropriate means, so that larger quantities of the culture liquid might be injected to increase, if possible, the vaccinating effect without endangering the life or stunting the future development of the animal.

In reducing the virulence, or attenuating it, as it is more commonly denominated, the following method was pursued: Tubes of peptone bouillon* inoculated with hog cholera bacilli were placed in a favorable temperature for multiplication (95 to 100°) over night. On the following day the culture liquid, now slightly clouded, was placed in an unfavorable temperature of 110 to 111° F. (43.5 to 44° C.) and kept there for about ten days. Thereupon fresh tubes were inoculated from these and subjected to the same process. From time to time rabbits were inoculated to test any attenuation that might have taken place, and it was noticed that there was a slight modification of the disease in rabbits after a time. After the bacteria had thus been exposed to a high, unfavorable temperature for more than two hundred days and passed through twenty cultures, a small dose of one-tenth cubic centimeter (one five-thousandth of a pint approximately) injected under the skin did not prove fatal to a rabbit, while larger doses were still fatal. Small quantities injected into an ear vein were likewise fatal. The reduction of virulence was therefore not very great, even after this very prolonged exposure to a high temperature. At the same time it was thought advisable to use it as vaccine *a*.

A second vaccine was prepared at the same time. It was exposed for only ninety to one hundred days, and passed through nine cultures in place of twenty, as with vaccine *a*. It was still virulent enough to kill rabbits in small doses, and in fact there was little

* Beef broth containing a little peptone and common salt.

difference between this and the original virus. This we shall call vaccine *b*.

The animals used.—The pigs that were chosen for vaccination numbered forty-eight in all. Of these twenty-seven were from one farm in the District of Columbia where no disease had existed among swine for years. They were all raised in pens. The remaining twenty-one were obtained from a farm in the District which likewise had been free from disease for a long time. They, however, had not been raised in pens, but were allowed to range over a large pasture. At the time of vaccination they were all about three months old. The first lot were the product of an Essex boar and Berkshire sows, pure bred. The second lot were mixed Jersey Reds and Chester Whites, grades. At the date of vaccination they weighed from 50 to 75 pounds each, the weight being slightly in favor of the first lot.*

A large pen had been built for this purpose, divided into compartments, which were separated from one another by tight board partitions. We will denominate for convenience the twenty-seven penfed swine as lot A, the twenty-one pasture-fed pigs as lot B. They were divided as follows:

In compartment 1	7 of lot B.
In compartment 2	7 of lot B.
In compartment 3	7 of lot B.
In compartment 4	empty.
In compartment 5	9 of lot A.
In compartment 6	9 of lot A.
In compartment 7	empty.
In compartment 8	9 of lot A.

The vaccination consisted in injecting a definite quantity of peptone bouillon, in which the attenuated bacilli had grown for about twenty-four hours, into one or both thighs according to the quantity used. The date of the two vaccinations and the quantity injected into each pig is given in the following table:

Compartment.	Lot.	October 18, 1889.	November 5, 1889.	
1	B.	Checks		
2	B.	10 cubic centimeters* vaccine *a*	4 receive $2\frac{1}{2}$ cubic centimeters	Vaccine *b*
			3 receive 5 cubic centimeters	Do.
3	B.	5 cubic centimeters vaccine *a*	4 receive 10 cubic centimeters	Vaccine *a*
			3 receive $2\frac{1}{2}$ cubic centimeters	Vaccine *b*
4				
5	A.	10 cubic centimeters vaccine *a*	4 receive $2\frac{1}{2}$ cubic centimeters	Vaccine *b*
			4 receive 5 cubic centimeters	Do.
6	A.	5 cubic centimeters vaccine *a*	4 receive 10 cubic centimeters	Vaccine *a*
			5 receive $2\frac{1}{2}$ cubic centimeters	Vaccine *b*
7				
8	A.	Checks		

*1 cubic centimeter is equivalent to $\frac{1}{125}$ gill or to $\frac{1}{30}$ fluid ounce approximately.

From this table it will be seen that the pigs received two injections each, eighteen days apart. Both lots were treated alike, while the quantity of liquid injected was varied somewhat. It will also be noted that some pigs from both lots received only vaccine *a* both times.

After the first injection and as a result of it one pig in compartment 5, belonging to lot A, died nine days after the injection. The spleen contained hog cholera bacilli. Thus but one out of thirty succumbed to vaccine *a*, and in this case death may have been due to

*The selection of pigs, arrangement of pens, and inoculations were made by Dr. F. L. Kilborne.

the accidental puncturing of a vein under the skin by the needle of the hypodermic syringe, by which means the bacilli may have been injected into the blood. This procedure is quite invariably fatal when large doses are used, as will be seen from the details of the experiment to be reported further on. Fourteen days after the second inoculation a second animal in the same compartment died, evidently as a result of it, since hog cholera bacilli could still be detected in the internal organs. Thus two out of thirty were killed by the inoculation, or $6\frac{2}{3}$ per cent., a proportion rather high for any method destined to have any practical value. But the problem before us now was to see whether any method of subcutaneous inoculation could be relied upon to give sufficient immunity to resist the natural disease. A method, sufficiently severe to lead to the death of $6\frac{2}{3}$ per cent. of the vaccinated animals should therefore in the sequel prove specially efficacious for those animals that survived it. This, however, did not prove to be the case.

Of the control animals two from compartment 8 died sixteen and twenty-one days, respectively, after the vaccinated animals had received the second injection of the vaccinal culture. In one there was found diphtheritic inflammation of the middle portion of the small intestines, in the other the mucous membrane of the large intestine was more or less inflamed. In neither case, however, could hog cholera bacilli or any other bacteria be detected in the internal organs. It might be inferred that this compartment had been infected by the vaccinated pigs. It will be seen, however, that the neighboring compartment was left empty and the greatest care was taken not to use utensils indiscriminately. Moreover the evidence of hog cholera, the presence of the bacilli in the body, was not obtainable. Meanwhile the check pigs in compartment 1, adjoining the vaccinated lot in compartment 2, showed no signs of disease.

It should also be noted that all four deaths were from lot A, the pen-fed pigs. Lot B stood the vaccination without any accident, and the checks remained well till the time of exposure to the natural disease. The effect of the injections manifested itself in general by a slight indisposition and a refusal to eat the daily ration for one or two days. The place of injection showed in most cases a subcutaneous tumor from 1 to 2 inches long.

The exposure to diseased pigs.—The two injections or vaccinations, as may be seen from the table, were made October 18 and November 5, 1889. On December 19, about one and one-half months after the last injection, the pigs were exposed to the disease. At this time there were twenty-three of lot A, of which seven were checks or control animals and sixteen vaccinated, and twenty-one of lot B, of which seven were checks and fourteen vaccinated; so that there were in all twenty-eight vaccinated and fourteen control animals to be exposed.

The animals in the different compartments, hitherto kept apart, were allowed to mingle by removing the partitions and thus making one large pen. At the same time eight infected and diseased pigs were placed in the pen with the rest. These had been infected on the station from an outbreak carefully studied, from which swine plague could be excluded with certainty. That the introduced disease was sufficiently virulent is shown by the fact that all eight infected pigs died between December 20 and December 27, at the rate of about one a day, beginning the day following their mingling with the vaccinated and control animals.

The result of the experiment was curious and quite unlooked for. The exposed pigs began to die on the 28th of December and continued to succumb until February, when apparently all the susceptible animals had been weeded out. The status of the experiment February 1 was as follows:

Of the lot of pen-fed pigs only one animal died, and this one of the check animals. It had been small and unthrifty before the exposure, and at the autopsy besides the rather mild hog cholera lesions there was a general anæmic condition manifest. Hence practically all of lot A resisted the disease, control animals included. The infection had been too mild for them.

With the other lot of pigs the case was different. At the beginning of the exposure there were fourteen vaccinated and seven control animals. At this time (February 1) there were left but three vaccinated and one control animal. The disease had made no discrimination between the treated and the not treated and had killed seventeen out of twenty-one. Of the whole lot remaining all were thriving excepting two or three, which were stunted in growth.

The inference to be drawn from these results is that the subcutaneous inoculations had little or no effect on the course of the disease. For lot A the disease was too mild, for lot B it was fatal in spite of the vaccination. This is practically the conclusion arrived at in 1886 when the experiments gave no better results than those just quoted. It may be possible that, by increasing the quantity of the culture liquid and the number of inoculations, a point may be reached at which immunity is produced. But such modification besides endangering the life of the animal would be too tedious and expensive to be of practical value.

There are some other not unimportant inferences to be drawn from this experiment. They bear upon the methods employed in testing the truth or falsity of subcutaneous vaccination and the evidence that can be adduced in its favor.

Had we chosen the pen-fed pigs to be vaccinated and the pasture-fed pigs as control animals we might have reached the erroneous conclusion that our vaccination was a complete success. Or had the circumstances been just the opposite—had the pasture-fed pigs been used for vaccination, the pen-fed for checks—we would have seemed justified in concluding that vaccination or preventive inoculation is not only a failure but predisposes swine to the natural disease. Neither of these inferences is correct, however, as the experiment proves. We should therefore be extremely cautious to accept any conclusions in regard to matters of such importance without the results of carefully conducted experiments before us. Experiments conducted in the field have at best but a partial value, since the disease may be introduced into a given herd or not depending on circumstances over which no proper control can be exercised, or else if the disease appears the animals are of different ages and of different degrees of health or else not exposed to the same dangers, etc.

Thus this experiment as well as those of former years afford sufficient evidence for the conclusion that the subcutaneous injection of culture liquid containing hog cholera bacilli is not capable of protecting swine from hog cholera.

In order to determine the effect of the vaccination and exposure upon the surviving pigs their weight was roughly estimated February 1. Of lot A the six control pigs had an average weight of 105 pounds each, the fifteen vaccinated ones about 93 pounds. The individual weights varied from 60 to 160 pounds, the heaviest being a

control animal. Of lot B the three surviving vaccinated animals weighed on an average 84 pounds each, and the surviving check or control animal 105 pounds. The vaccination had thus the effect of slightly reducing the body weight in comparison with the control animals.

A few additional experiments were made with this lot of pigs which may be very briefly summarized:

March 18, 1890.—One cubic centimeter of a peptone-bouillon culture of the hog cholera bacillus was injected into one of the crural veins of two control and four vaccinated pigs, all from lot A. Of these six animals one control died six days later. The others recovered. This showed that some immunity had been gained by the vaccination.

April 18.—Six other pigs from lot A, two control and two vaccinated animals were fed each with nearly a quart of viscera from hog cholera cases. All survived.

April 29.—Another and final test was made by taking the five pigs of lot A, which had survived the intravenous injection of March 18, together with four others of the same lot and two of lot B, not thus treated March 18, and injecting into the crural vein another dose of bouillon culture of hog cholera bacilli. Three of those which received the injection of 1 cubic centimeter March 18 now received the large dose of 5 cubic centimeters. All the rest received 2½ cubic centimeters.

Of these eleven animals thus inoculated three died within two, four, and forty-two days, respectively, after the inoculation. These three belonged to the lot of six which had not previously received the intravenous injection. The other three survived. Expressed in another form, of those which had received the intravenous injection March 18 100 per cent. survived; of those which had not received it 50 per cent. survived. Of the three which died, the two which died in two and four days after the injection belonged to the original check animals, the one which died forty-two days after was a vaccinated animal.

These last tests lead to the inference that injections of hog cholera bacilli into the veins in small quantity protects the animal against injections of large doses ordinarily fatal.

The history of the surviving vaccinated animals up to November 1, 1890, may be given very briefly. They were kept in the same pens in which they had been exposed to the disease. Three died subsequently, two being in very good condition at the time of death. In one (June 22) there was a rupture of the œsophagus at its insertion into the stomach, permitting the contents of the stomach to enter the chest cavity. The second (September 3) was not examined. The third died from enlargement and softening of the bones of the head, impeding respiration. The remaining animals weighed from 140 to 280 pounds apiece. Those that received the injections into the veins were the poorest in weight.

AN EXPERIMENT TO TEST THE VALUE OF INJECTIONS OF HOG CHOLERA BACILLI INTO THE VEINS AS A MEANS OF PRODUCING IMMUNITY.

The preceding test had shown that two injections of hog cholera bacilli under the skin had no appreciable effect in protecting swine from the disease itself. Subsequent experiments with the same lot of animals proved that when small doses of hog cholera bacilli are

injected directly into a vein the animal so treated is able after a time to resist fatal doses administered in the same manner.

The plan laid out for this experiment was to inject into a vein of the leg a very small quantity of culture liquid containing hog cholera bacilli to begin with; then after a certain period of time, depending on the effect produced by the first inoculation, to inject a larger dose in the same manner, and perhaps a third dose still larger, using control animals to gauge the effect of the various doses on fresh pigs; finally, to expose these inoculated animals to the natural disease.

The actual experiment carried out may be briefly summarized: Twenty-five pigs were selected, and at the time of the first injection they were about seven months old, in good condition, and weighing from 75 to 90 pounds each. The culture employed was derived from an outbreak studied in 1889 and somewhat attenuated by age.

On August 23 thirteen pigs of this lot received the first injection. Five received one-eighth of a cubic centimeter of a peptone-bouillon culture, five one-quarter of a cubic centimeter, and three one-half of a cubic centimeter each. In every case the small dose was diluted with some sterile liquid, such as beef broth to bring it up to 1 cubic centimeter. On the following day all pigs were sick and in proportion to the dose received. This was shown by a refusal to eat, and lasted but one or two days.

On September 4, twelve days after the first injection, only one pig had lost weight. They were all inoculated in the same way with 1 cubic centimeter each, and in addition four fresh pigs with the same dose. After one or more days of slight illness following the inoculation they all recovered, excepting the four fresh pigs. These grew thin and weak, and two died September 29.

On October 17 a final injection of 5 cubic centimeters was given to all surviving pigs and three fresh ones. The result of the inoculations is given in a more condensed form in the following table:

Table giving the results of intravenous inoculations of culture liquid containing hog cholera bacilli.

Pig. No.	August 23.	September 4.	October 17.	Remarks.
347	⅛ cubic centimeter.	1 cubic centimeter.	5 cubic centimeters.	November 8, condition good.
348	....do	....do	....do	November 8, stunted.
349	....do	....do	....do	November 8, condition good, swelling and ulceration over left tarsus.
350	....do	....do	....do	November 8, condition fairly good.
351	....do	....do	....do	November 8, condition very good.
359	¼ cubic centimeter.	....do	....do	November 8, condition fair, crippled by swelling on feet.
364	....do	....do	....do	November 8, condition good.
365	....do	....do	....do	November 8, condition very good.
366	....do	....do	....do	Dead October 21.
367	....do	....do	....do	November 18, stunted.
256	½ cubic centimeter.	....do	....do	November 18, condition good.
357	....do	....do	....do	Do.
358	....do	....do	....do	November 18, condition fair, swelling and sores on all feet.
352	....	....do	....do	Dead October 20.
353	....	....do	....	Dead September 29.
354	....	....do	5 cubic centimeters	November 18, condition good, enlargement of left fore and hind feet.
355	....	....do	....	Dead September 29.
361	....	....	5 cubic centimeters.	Dead October 21.
362	....	....	....do	Dead October 23.
363	....	....	....do	Dead October 29.

From this table we learn that the three last control animals died three, four, and six days, respectively, after the inoculation. This indicates a decided immunity on the part of those which received the two previous injections, since but one of these thirteen succumbed to the last inoculation on October 21, or in other words, 100 per cent. of the last control animals and but 7 per cent. of the previously inoculated animals died as a result of the last injection (which has thus far always proved fatal to pigs).

When we come to the four control animals of the second inoculation (Nos. 352 to 355 inclusive) which received 1 cubic centimeter to begin with, we find that two of these died as a result of the inoculation, the third died as a result of the last inoculation, and the fourth survived.

Although this method thus showed that pigs can be made more or less insusceptible to fatal doses injected into the veins, it is not as yet proven that it will eventually prevent the treated animals from acquiring the disease in the ordinary way. We have thus far been unable to expose these animals, since no outbreak has been found during the fall within reach to furnish the starting point at the Experiment Station.

Another point deserves consideration, and this is the effect of this method of inoculation. If we examine the remarks appended to the twelve cases which were inoculated three times, we learn that only seven are in good condition, two are stunted and small, and three are affected with enlargement and ulceration of the feet (from the carpal and tarsal joints down) though otherwise in good condition. These injuries are most likely the result of the inoculations, which one it is impossible to state, and may be directly due to the injected bacilli lodged in the bones perhaps and causing their destruction. How much damage will be done thereby can not be surmised at this time.

SWINE PLAGUE.

The standpoint of pathologists and students of infectious diseases both in man and animals at the present time is that two diseases must be regarded as identical or dissimilar according as the causes which produce them are the same or different. Two maladies in many respects the same are yet different from one another if the bacteria which produce them are different. Not only is this standpoint theoretically correct but sound also from a practical point of view, for the simple reason that only an exhaustive study of the causes of disease can eventually help us in suppressing them. While pathology has done but little in the treatment of infectious diseases of man and animals, most authorities being opposed to any treatment as useless and dangerous, it has already done much in formulating rules for the prevention of such diseases by tracing the insidious ways by which diseases are carried from place to place and introduced into herds of animals, by studying the nature of the virus, its vitality under various conditions, and the agents which are capable of destroying it.

All these important facts result from the study of the disease-germ in the laboratory, in the diseased animals, and in nature. Hence it follows that the disease-germ is the most important factor to be studied before other problems can be solved and before any sound information concerning the disease itself is obtainable. It also follows from these considerations that it is of essential impor-

tance to recognize the specific disease-germs wherever they may be found. This study of bacteria or bacteriology lies therefore at the basis of all investigations of infectious diseases and upon it subsidiary investigations relating to vaccination, inoculation, and treatment must rest.

Two infectious diseases of swine have been recognized in the investigations of the past five or six years, denominated, respectively, hog cholera and swine plague. The specific bacteria which cause them, and which can be made to reproduce them by inoculation, are readily distinguished by any novice in bacteriological studies. Their differences are sufficiently pronounced to demand careful separate investigations, although the diseases themselves may be easily confounded and may occur side by side.

It has been maintained in some quarters that this position of the Bureau of Animal Industry in insisting upon the existence of two distinct infectious swine diseases is wrong and that there is but one disease in the country demanding attention. This latter position may be due either to inability to distinguish between the germs causing these diseases, to inability to find them in diseased animals by not applying appropriate methods, or else to the nonexistence of one of these diseases in that part of the country where the investigations were made.

No amount of time and labor has been spared in the study of these two diseases, especially swine plague, in order that a thorough knowledge of its nature might be obtained. During midsummer of this year we had the good fortune to find an outbreak of swine plague on the coast of New Jersey, several miles from Pleasantville and Atlantic City. The owner of the herd in which the disease had broken out, Mr. Joseph Young, gave us all the assistance in his power and freely sacrificed his animals for the purpose of investigation.

The history of the outbreak may be stated very briefly as follows: In May of the present year the owner purchased two lots of pigs from a dealer, numbering ninety-seven in all. At the time of the purchase more or less coughing was noticed among some unthrifty animals in the lots. On the farm they were kept on dry, sandy soil, and fed with hotel slops from Atlantic City. The coughing did not entirely disappear, and on July 1 they began to die. Up to July 19 thirty-four had perished. July 20 four died, July 21 seven died, and on July 22 eight died. These few facts indicate a very virulent and rapidly fatal disease. It was without doubt brought with the pigs themselves, as there had been very few pigs and no disease upon the farm for years, nor was any disease reported among swine in the vicinity though fed and kept in the same way.

The symptoms noticed by the owner were coughing, loss of appetite, and emaciation. Vomiting was a common occurrence. The sick animals were in the habit of straying and hiding themselves in out-of-the-way places and under bushes. Some died within three to five days after the first symptoms of disease; others lived a few days longer. Some died suddenly without manifesting any signs of disease.

From this herd about seventeen animals were examined after death. Ten of these were examined on the farm between July 21 and 23 inclusive and cultures made from the internal organs of six. This part of the work could not be done very thoroughly, owing to the primitive facilities and the innumerable insect pests on the farm. The re-

sults of this work indicating that we had an outbreak of swine plague instead of hog cholera to deal with as we had anticipated, it was deemed advisable to make a more thorough investigation of this disease. Dr. Kilborne was therefore directed to return alone to this farm July 28, and send to the Experiment Station at Washington some sick animals where the disease could be more carefully investigated in connection with the laboratory. On the farm two more autopsies were made on dead pigs and five diseased ones sent by express to the Experiment Station. Of these latter one died on the 1st, three on the 3d, and one on the 5th of August. Subsequent information from the owner showed that only seven out of the entire herd had survived the infection, *i. e.*, about 8 per cent.

It would be out of place in this brief report to go into detail concerning the appearance presented on *post-mortem* examination of the affected animals. In general both lungs and intestines were diseased and the impression made upon the writer at first was that of an outbreak of hog cholera. The disease resembled very closely that studied in Iowa in 1888, and the belief at that time on making the *post-mortem* examination in several herds was that the disease was hog cholera in some herds and swine plague in others. As in the Iowa disease, so in this New Jersey outbreak, the impression that the disease was hog cholera was entirely dispelled by the bacteriological work, as will be shown further on.

As regards the lungs, these were consolidated more or less in ten out of the seventeen cases. The hepatization was in most cases accompanied by pleurisy of varying degrees of severity and more rarely by pericarditis. The spleen and lymphatic glands were engorged with blood in the majority of cases. The mucous membrane of the stomach was usually deeply congested and in a few cases portions of the membrane had undergone mortification or necrosis.

In the large intestine there was disease in almost every case. This disease was manifested by a general reddening or by discoloration and pigmentation of the mucous membrane, by more or less extensive diphtheritic inflammation, causing superficial necrosis or mortification and by isolated ulcerations. In nearly all cases ulcers were present. It is not surprising that hog cholera and swine plague should be regarded as one disease when the lesions they produce are so much alike to the casual observer.

In order to determine the true nature of the disease it became necessary to learn whether hog cholera or swine plague bacteria were present or whether perhaps some third unknown germ could be regarded as cause of the disease. Cultures were, therefore, made from the organs of six animals on the farm and from five animals in the laboratory. The result of this laborious work was that no hog cholera bacilli were found in any of the cultures made from these eleven animals. They manifestly had nothing to do with the disease. In four out of the eleven cases swine plague bacteria were found distributed through the organs of the body. In the remaining cases most of the cultures from the organs remained sterile. A few contained other bacteria of a miscellaneous character, most of them known from former investigations.

The disease-producing power of the swine plague bacteria from this outbreak is well illustrated by the two following experiments made subsequently:

Inoculation of healthy pigs.—Two pigs three months old and weighing 40 pounds received into a vein of the leg 1 and 5 cubic centime-

ters, respectively, of a peptone-bouillon culture of the swine plague bacteria derived from this outbreak. The animal which had received 5 cubic centimeters was dead within sixteen hours. There was more or less redness of the skin, œdema of the lungs, commencing peritonitis, hemorrhagic condition of the kidneys, and congestion of the mucous membrane of the stomach. The pig which had received but 1 cubic centimeter died in four days. There was found at the autopsy extensive double pleuritis, pericarditis, and consolidation of a small portion of the left lung. The kidneys contained numerous abscesses. At the same time a third pig was inoculated by injecting 5 cubic centimeters of the culture liquid into the right lung. This animal died within twenty-four hours with pleuritis, beginning hepatization of the lungs, peritonitis, and pericarditis. These results are indicated to show how virulent the swine plague germ of this outbreak was and that the destructive activity of this germ is fully equal to that of the hog cholera bacillus.

In order to test the effect of feeding substances containing this germ the organs of six rabbits which had been inoculated with it were fed to two pigs. They showed no signs of disease. A subcutaneous injection of 5 cubic centimeters of culture liquid was likewise without effect. The negative result following these methods of introducing the swine plague germ into the body simply confirms former experiments of a similar character with swine plague germs from other outbreaks.

Exposure of healthy pigs to sick animals from this outbreak.—The five pigs sent to the Experiment Station were placed in a wooden pen with two healthy pigs. One of these died eleven days after with a large number of necrotic masses in the lungs, exudative inflammation of the pleura and pericardium, intense hyperæmia of the stomach, and portion of the large intestine. Swine plague germs were detected in lungs and intestines. The other pig exposed at the same time became very unthrifty and was killed several months later. No disease could be detected, but the weight of the animal at the time it was killed was but 25 in place of 70 or 80 pounds. Three other healthy pigs were placed into this pen, one of them while two of the diseased pigs were still alive, the remaining two when all of the original lot had died. These three exposed pigs also survived, but they became unthrifty and after several months they were all over 50 pounds behind in weight. The explanation of this condition is by no means obvious, although it would appear that the infection disappeared in great part from the pen with the death of the diseased animals and that more direct contact with such diseased animals is necessary to produce a fatal result in swine plague than in hog cholera.

Little need be said in this connection of the swine plague germ itself. It did not differ from the same germ obtained from various sources since 1886, and described in detail in the reports of the Bureau of Animal Industry issued since that date, excepting perhaps in its greater virulence. A very minute quantity of growth from cultures placed beneath the skin of rabbits proves fatal in less than sixteen hours. Its fatal effect on guinea pigs and mice is no less pronounced. These small animals are thus of great service to the pathologist in exactly gauging the virulence of the same germs from different localities.

The investigation of this outbreak of swine disease has once again demonstrated the existence of a highly infectious, extremely fatal dis-

ease, which can not be included under hog cholera, and which without difficulty may be ranked with hog cholera in economic importance to the farmers of the country.

Its mode of introduction into a herd is probably mainly through sick animals, which are suffering from the disease in a chronic form and are the remnants of other outbreaks sold by unscrupulous persons or those who are not aware of the dangers and losses to which they may subject owners of swine into whose herds these remnants are taken.

The disease still awaits a complete explanation of its various characters, however, more especially as to any other channels by which it may be transmitted from herd to herd, from animal to animal, and its capacity for thus transmitting itself, which capacity was very feeble in the disease after it had been brought to the Station. Meanwhile the same rules of prevention* and for the application of disinfectants apply to both swine plague and hog cholera, although there are points of difference which need not be dwelt upon in this connection.

TWO OUTBREAKS OF HOG CHOLERA.

Two other outbreaks of swine disease may be briefly mentioned, inasmuch as there was no difficulty in making the diagnosis of hog cholera.

A limited outbreak was reported as having occurred in the District of Columbia, a few miles from Washington City, during September. There were eight in the herd, all of which died with the exception of one, which was brought to the Experiment Station for examination. After lingering several weeks it also died. The most important lesions found were superficial necrosis of the ileum and about a dozen large ulcers in the large intestine. *The lungs were normal and in the spleen hog cholera bacilli were detected*, which produced by inoculation the characteristic disease in rabbits.

The disease was traceable to the Washington market, where the animals were purchased. This is not the first time that outbreaks in the vicinity of Washington have been traced to this source.

Another outbreak was investigated by Dr. E. C. Schroeder at Quantico, Virginia, during October, whose report may be briefly summed up as follows:

On October 28 Dr. Schroeder made *post-mortem* examinations of two pigs which had been dragged from the farms where they belonged to the common to be disposed of by the buzzards. One had been dead one or more days, the other was still warm, having died very probably only a few hours before. In the first animal were noted enlarged spleen, reddening of mucous membrane of the stomach, numerous ulcers in the large intestine. In the lungs were a few small collapsed areas, otherwise they were healthy.

In the second animal the lesions were practically the same. There was no consolidation of lung tissue as in the preceding case. From the spleen of this animal cultures were made and these contained only hog cholera bacilli, which produced in rabbits the peculiar and characteristic inoculation disease of the hog cholera germ.

Dr. Schroeder furthermore was informed that hundreds of pigs had perished of hog cholera this season. The manner of disposing

---

*See Report of the Bureau of Animal Industry for 1887–'88, page 148; Bulletin on hog cholera, page 123; report of the Secretary of Agriculture for 1888, page 156.

of the carcasses mentioned above, as well as the custom there prevalent of allowing swine to roam at large over the country does not make this extension of the disease appear at all surprising.

INVESTIGATION OF E. A. V. SCHWEINITZ, PH. D.

The following is a brief account by Dr. E. A. v. Schweinitz of the chemical investigations conducted under the direction of the chief of the Bureau of Animal Industry into the nature and effects of the chemical products developed during the growth of the microbes of hog cholera and swine plague:

In January, 1890, the writer was appointed to take charge of the chemical work of the Bureau of Animal Industry and investigate the chemical side of the diseases of animals, especially hog cholera and swine plague. It was necessary first of all to secure laboratory room suited to this class of investigation. On account of the crowded condition of the offices of the Department, space was procured by partitioning off rooms in the Museum building. This laboratory was supplied with water, gas, and steam, the necessary working desks, apparatus and chemicals, and by April 1 it was in proper condition to begin the investigations.

HOG CHOLERA.

The first problem undertaken was the study of the culture liquids of the hog cholera germ. Investigations of recent years have shown that when different disease germs are allowed to multiply in artificial nourishing media, as beef broth, they form substances which have the general composition of alkaloids and proteids, and give a number of the chemical reactions characteristic of these two classes of bodies. The alkaloids formed by germs are called, as a class, ptomaines, and the proteids, albumoses. Some of these substances, that have been isolated, are very poisonous in small doses; others only slightly so, or not at all. The fatal effects of a number of diseases which are known to be produced by specific germs are held to be due to the fact that the multiplication of the germ in the animal organism, just as when allowed to grow upon artificial media, forms large quantities of these poisonous alkaloids and proteids, which in their turn produce death.

This suggests the inquiry: If this be true can not these poisons be isolated by chemical methods and their exact nature and properties determined? Further, is it not possible by giving small doses of these poisons at a time to so accustom the animal organism to their effect that a subsequent large dose of the same poison, even when produced in the body by the active multiplication of the germ, would not result fatally? That this object may be accomplished by treating animals with sterilized artificial culture media, in which the germ had been allowed to grow for some time, was demonstrated by the work of this Bureau upon pigeons in 1887.

The problems for solution were:

(1) To isolate the chemical compounds, alkaloidal and albuminoidal, which the hog cholera germ forms.

(2) Determine whether one or more of these compounds exist in the artificial culture liquids.

(3) Which are the important ones?

(4) Will the isolated compounds produce immunity in animals from the disease of hog cholera?

(5) What is their exact chemical constitution?

(6) Are there known compounds of the same or similar composition, or one that can replace them?

(7) Can these compounds be made artificially?

(8) Can chemical inoculation be made practical, and if so, what is the minimum amount of substance and time required?

The results of the experiments permit of positive answers being given to all of these questions except the last so far as the disease of hog cholera is concerned, and only some details remain to be worked out.

After a number of experiments we found that acid beef infusion containing one half per cent. of peptone is the most satisfactory medium in which to grow the bacillus of hog cholera. Erlenmeyer flasks of 500 cubic centimeter capacity were used to contain the liquids, the mouths of the flasks being closed with a cotton plug, and after inoculation allowed to stand in the incubator at 37° C. for two to three weeks. The liquids had by this time become alkaline in reaction and careful examination showed that there was no contamination with foreign germs. In isolating the chemical products from these solutions the methods by which Brieger has obtained such excellent results were with slight modifications followed.

The culture liquid, after being neutralized with dilute hydrochloric acid, was evaporated on the water bath. The residue was then extracted with 96 per cent. alcohol and the filtered solution treated with mercuric chloride. A heavy crystalline precipitate was formed which increased upon standing. After filtration this precipitate was treated with water, decomposed with sulphuretted hydrogen, and the mercury sulphide removed by filtration. From the filtrate, after removal of the excess of sulphuretted hydrogen and concentration, I was able to isolate cadaverine and methylamine. The filtrate from the mercuric chloride precipitate was freed from excess of mercury by sulphuretted hydrogen, and the mercury sulphide filtered off. The residue, after concentration of this filtrate, was extracted with absolute alcohol, the solution thus obtained showing the presence of a salt of an alkaloidal character. The reactions were as follows:

With phosphomolybdic acid—light yellow precipitate;
With bismuth potassium iodide—red needles;
With phosphotungstic acid—a white precipitate;
With potassium iodide and iodine—brown red precipitate;
With platinum chloride—yellow crystalline precipitate;
With gold chloride—yellow red crystalline precipitate.

Subsequently the use of mercuric chloride was omitted, and repeated extraction of the residue with alcohol alone substituted.

The double salt obtained with platinum chloride was submitted, after crystallization from 96 per cent. alcohol, to preliminary analysis, giving results which correspond to the formula, $C_{14}H_{34}N_2PtCl_6$. The free base I have not yet succeeded in obtaining in a pure form. The hydrochloride of this base is soluble in absolute alcohol as well as water, and can be obtained as needle-like crystals.

By treating the original culture liquids of the hog cholera germ with a large excess of absolute alcohol, a white flocculent precipitate was obtained, a portion of which was soluble in water and could again be precipitated by alcohol. By repeated treatment of this sort with water and alcohol a small quantity of an albuminoid body containing carbon, hydrogen, nitrogen, oxygen, and sulphur, was finally obtained. This substance, which we will call albumose, was dried

over sulphuric acid in vacuo, giving white translucent crystalline plates. After drying it was still soluble in water, though dissolving with more difficulty. The water solution gave with platinum chloride an almost soluble precipitate, appearing under the microscope as needle-like crystals. The composition of this platinum salt shows it to be a substance allied in composition to peptone. As to the exact nature of this latter substance, whether it is a true proteid or belongs to the class of ferments, remains to be determined by subsequent study and investigation.

Brieger and Fraenkel (*Ber. Klin. Woch.*, 1890, No. 11), who have extracted a similar substance from culture liquids of the diphtheria, tetanus, and cholera germs, and Baginsky and Stadthagen (*Ber. Klin. Woch.*, 1890, No. 13), who obtained an allied body from cultures of the cholera-infantum germ, hold that the substances are proteids. Roux and Yersin (*Annales de l'Institut*, Pasteur, 1890, p. 385), on the contrary, hold that the substances obtained by the precipitation with alcohol are ferments. Hankin (*British Medical Journal*, July 12, 1890, p. 65), who has also isolated a substance from cultures of anthrax possessing albuminoid properties, holds the same view as Brieger and Fraenkel, that the body in question belongs to the class of proteids.

In so far as our work upon the hog-cholera culture liquids goes, we are inclined to the opinion that we have to deal with albumoses, which can be heated in presence of acids to 70° without decomposition. I am preparing now a considerable quantity of this albumose and hope to be able in a short time to have something more definite as to its exact nature. To be sure that the substance one is dealing with is absolutely pure is very difficult when it is a body of this nature, and only extended experiments can be regarded as conclusive.

As to the nature of the new ptomaine which has been isolated, we will not go into a discussion of its exact chemical composition until it is more definitely determined.

In order, however, to distinguish the active principles formed by the hog-cholera germ, I have named the ptomaines as a class sucholotoxins, and the new base sucholotoxin (from the Greek Σῦς, a hog, Χολέρα, cholera, from Χολή, bile, and Τοξικόν, poison). To the proteid body I have given the name sucholoalbumin. These names will be used in referring to these bodies in the future.

Some experiments were made later, but may be inserted here, in regard to substituting some other material for peptonized beef infusion in furnishing nourishing media for the artificial cultivation of the germ. Potato broth, pea broth, and plain beef infusion have been used. In all of these the hog-cholera germ grows very vigorously, forming the ptomaines and albumoses, but not in so large a quantity as in the peptonized beef infusion.

Now, in regard to the toxic effect of the sucholotoxin and sucholoalbumin, active poisons for guinea pigs, in small doses, they are not. In large doses, corresponding to from 6 to 15 cubic centimeters of the culture liquid, death is produced in guinea pigs in from six to twenty-four hours. A small subcutaneous injection causes the animal to appear stupid and uncomfortable for a short time, fifteen minutes, produces a slight rise in temperature, necrosis of tissue, and ulceration at the point of injection.

It may be added here that in making these and all the following experiments special precautions were taken to prove that the mate-

rial used was entirely free from germs. Cultures were always made from the substances used for injection.

The autopsy of a case resulting from poisoning with the ptomaines may be inserted here: Liver, pale and fatty; subcutaneous tissue over abdomen necrosed, and infiltrated muscle soft and friable. Other organs apparently normal.

The next point to be decided was: Can immunity be produced from hog cholera by previously treating the animals with these substances, isolated from the culture liquids? The results are recorded in the following experiments, which are very conclusive. For the laboratory experiments guinea pigs were used as being convenient to handle and susceptible to hog cholera. They have proved very satisfactory.

The first of our experiments that we will record were made with sucholotoxin.

Experiment I.—Two guinea pigs, each weighing about three-fourths of a pound, were treated with a solution of about 0.05 gram of sucholotoxin hydrochloride each. The solution was introduced under the skin of the inner side of the left thigh. Immediately after the operation the animals appeared uncomfortable, but were not made ill. For a few days there was a rise in temperature and also a slight swelling at the point of inoculation, which, however, disappeared in about five days, and the animals were then well.

Two more guinea pigs were now selected as checks, approximately of the same size and weight as those which had been treated, and the four animals were then inoculated with 0.1 cubic centimeter of hog cholera virus each (0.1 cubic centimeter beef infusion peptone culture one day old, plus 0.2 of sterile, normal salt solution). This is the dose which previous experiments made in the Bureau had shown to be the proper quantity to kill a guinea pig in from eight to ten days. The inoculations with the virus were also made subcutaneously in the thigh. The checks died in eight and nine days.

Of the animals which had been first treated with the substance mentioned, and afterwards inoculated, one died two days after the last check. The other guinea pig of this set was quite ill for ten days, with a large swelling at the point of inoculation. This finally opened and healed, and the animal was quite well within three weeks after the inoculation, and has continued so to date—five months.

Experiment II.—The next series of experiments were made with sucholoalbumin from beef infusion peptone culture media.

Two guinea pigs were again selected and treated with about 0.008 gram each of sucholoalbumin. There was a slight rise of temperature in the animals and the formation of a small, hard lump at the point of injection. This disappeared by the eighth day and the animals were quite well. Two more guinea pigs were now taken as checks, and all four animals were inoculated with 0.10 cubic centimeter of hog cholera culture. The checks died within seven days. The *post-mortem* appearances were practically the same as those noted in the first series. The two guinea pigs which had been treated with the sucholoalbumin died *ten* days after the checks. This indicates considerable resistance to the disease. Several other experiments were made by treating guinea pigs with the albumin in varying quantities, all showing resistance, and subsequently immunity.

Experiment III.—Three guinea pigs were treated with sucholoalbumin, 0.1 gram being given to each, subcutaneously in the

thigh. The albumin for two of the animals was derived from cultures containing blood serum, the albumose given to the third was from ordinary beef infusion peptone culture. Ugly ulcers formed at the point of inoculation, which healed, however, in from ten to fourteen days, and the animals, with the exception of a slight rise of temperature, were well.

Two checks were again selected and the five animals were inoculated with 0.10 cubic centimeter hog cholera virus. The checks died, respectively, in eight and ten days from hog cholera. The animals which had received the preventive treatment were slightly ill for a few days with swelling at the point of inoculation, which finally opened and then healed nicely, and within a week the guinea pigs were well.

Three weeks after the inoculation one of these animals was chloroformed and examined *post-mortem*. Not the slightest scar could be discovered, all the organs appeared perfectly normal, and no germs were found.

Experiment IV.—Four guinea pigs were treated, two with a mixture of sucholotoxins, two with sucholotoxin and albumin. The injections were made as before, subcutaneously in the thighs, and at intervals extending over a period of four weeks. The sore caused by each injection was allowed to heal before the next one was made. After the animals had recovered from the last treatment two checks were selected, and the six were each inoculated with one tenth cubic centimeter hog cholera virus. The checks died, one in eight and the other in ten days, the *post-mortem* examination showing characteristic hog cholera lesions. The animals having the preventive treatment were ill about four days, those that received only the sucholotoxins being more dull than the others. There was also slight swelling at the point of inoculation with the germ, which subsided in ten days, after which the animals were perfectly well, and have remained so four months.

Experiment V.—Six guinea pigs were inoculated for this experiment, two with solution of the sucholotoxin and four with a solution of the mixed sucholotoxins. The sucholotoxin solution produced only slight local lesions, while the mixed toxins caused ulceration at the point of injection which did not heal for two weeks. The animals having by this time recovered, the test experiment with hog cholera virus was tried. Four of the animals mentioned above were taken—two from each set—and also two checks, and the six were inoculated. The checks died in eight and nine days, the autopsies showing the characteristic conditions of death from hog cholera. Those that had the preventive treatment were ill and dull for from four to six days after the inoculation. At the point of inoculation there was also some swelling and infiltration, very slight, however, compared with the similar swelling on the checks. In the treated animals the swelling sloughed and healed, and within ten days after the inoculation they were perfectly well. To test the resistance of the animals that had been treated by this method to ordinary exposure the following experiments were conducted.

Experiment VI.—Two guinea pigs that had received the preventive treatment, two blanks—*i. e.*, animals that had received no treatment—and two check animals that were inoculated with hog cholera virus were placed in one large cage. The checks became ill and died in eight or nine days from hog cholera. During this time the cage was cleaned only three times, so as to give full and free oppor-

tunity for contagion. One week after the checks had died one of the blanks became ill, and died within ten days. The autopsy showed hog cholera lesions. The second blank became ill a few days after the first blank succumbed, and died within thirty days. The animals which had the preventive treatment are now and have been quite well, though continually exposed for five weeks to every opportunity for contagion.

These experiments have answered conclusively the first five propositions named in the beginning of this report, and brings us to the sixth. Can these substances be replaced by one of allied composition and character that we already know and can prepare synthetically in the laboratory? The experiments also give an affirmative answer to this problem. If the ptomaines when introduced into the system produce certain changes, or induce certain powers of resistance on the part of the animal to subsequent doses of the poison, then it is possible that not only this one particular alkaloid but several, belonging to the same class and of approximately the same chemical composition, should produce similar effects when introduced into the system, as the true ptomaine extracted from the culture liquids, and subsequently immunity should result, when the animal should be exposed to the virus of hog cholera. I thought of a substance which could be prepared without difficulty, and which I will refer to as pure chemical. Some of it was prepared and the solution used for injection. The injections and treatment were conducted in the same manner as already recorded for the other guinea pigs, three animals being used for this experiment.

Experiment VII.—There was a slight rise in temperature of the animals and swelling and soreness at the point of injection. After this had healed these animals and two checks were inoculated with one tenth cubic centimeter of hog cholera culture. The checks died in eight and nine days. The animals which had been previously treated became ill, two dying five and six days after the checks. The third entirely recovered.

Experiment VIII.—One guinea pig was treated with a solution of the chemical in the same way as the previous experiment, except that a somewhat larger dose was given. Two pigs were again taken for checks, and the three inoculated with 0.1 cubic centimeter hog cholera culture. The checks died in six and seven days, respectively, of hog cholera; the treated animal recovered entirely. In the treated animal there was a slight swelling at point of inoculation with the germ, but this gradually decreased, finally opened, sloughed, and healed within a few days after the death of the checks.

Experiment IX.—Four guinea pigs were treated with a solution of the chemical substance. This modification of the injections was adopted, *i. e.*, very small quantities were used at a time and the dose repeated every day. The local irritation was in this way much diminished and what soreness was produced healed more rapidly. Two checks were taken and the six animals inoculated with 0.1 cubic centimeter of hog cholera culture. The checks died of hog cholera in eight days, one vaccinated pig in thirteen days, the others recovered.

Experiments were also made in producing immunity with the ptomaines obtained from the potato, pea, and simple beef broth cultures, which resulted successfully.

Two of the guinea pigs which had recovered from experiment IV, and two that had recovered from experiment V, were now reinoculated with double the dose of hog cholera virus used in the first test.

Checks were taken and given one half dose in quantity of the virus. These died in eight and nine days. The other pigs were a little stupid for a day or so, but at no time ill, and have since remained perfectly well.

One pig from experiment V, and one from experiment III, were chloroformed four or five weeks after their recovery, and an autopsy made. All the organs appeared perfectly normal, not even a scar being left at the point of injection, and the immunity produced was therefore perfect.

Our experiments had now proved that the chemical principles produced by the germ could be isolated; that their injection into guinea pigs rendered the animals secure against an attack of hog cholera, and that we have at hand a compound fairly easily obtained which will give the same results in securing immunity.

EXPERIMENTS UPON HOGS.

The next question was: Will these same materials produce immunity in hogs, and can the production of immunity by this method be made practical? The experiments were carried on at the Animal Experiment Station of the Bureau. The injections were made by Dr. Kilborne, who recorded the notes upon the condition of the animals. Necessarily the hogs were not as easy to handle as the guinea pigs, and the first experiment, which is the only one complete at this time, is not conclusive; but considering the time which must elapse before a question of this sort can be positively decided we regard the ultimate practical solution of the problem only as a question of detail, which a few more experiments will enable us to decide.

In order to test the value of this ptomaine, which had proved so satisfactory for guinea pigs, and also of the synthetically prepared chemical compound upon hogs, the following experiment was conducted:

Nine pigs, black Essex grade, aged three months, were selected, four of them being placed in one pen and five in another.

Pig No. 374, aged three months, weight 60 pounds, treated on July 26 with solution of the ptomaine, 18 cubic centimeters of solution were used, the injection being made subcutaneously at three points. On July 30 there was a large swelling at seat of injection. By August 8 this had sufficiently healed to permit of injecting more of the solution of the ptomaine. The dose was repeated on August 16. August 20 there was swelling (lumps the size of a hen's egg), at the points of injection. These sores had healed by sloughing, and on September 9 the animal was inoculated in the femoral vein with 2 cubic centimeters of beef infusion peptone hog cholera culture, one day old.

Pig No. 375, aged three months (weight 60 pounds), was treated in the same way as pig No. 374, with solution of the ptomaines, and showed the same soreness and symptoms. On September 9 inoculated with 2 cubic centimeters of hog cholera beef infusion peptone culture one day old.

Pig No. 376, aged three months (weight 50 pounds), treated with ptomaines as other two and inoculated September 9 with 2 cubic centimeters beef infusion peptone hog cholera culture.

Pig No. 377, aged three months (weight 50 pounds), treated on same dates as the above with a solution of the synthetical compound and inoculated September 9 with 2 cubic centimeters beef infusion peptone hog cholera culture one day old.

Pig No. 378, aged three months (weight 45 pounds), treated in same way as pig No. 377, and inoculated September 9 with 2 cubic centimeters beef infusion peptone hog cholera culture.

Pig No. 379, aged three months (weight 60 pounds);
Pig No. 380, aged three months (weight 69 pounds);
Pig No. 381, aged three months (weight 50 pounds);
Pig No. 382, aged three months (weight 50 pounds), were all inoculated in the vein on September 9 with 2 cubic centimeters beef infusion peptone hog cholera culture one day old. These served as checks to Nos. 374 to 378, inclusive.

The results of this experiment were that of four checks three died, two in four and five days after the inoculation with the germ, the third in seventeen days, and the fourth check recovered.

Of the three pigs treated with the ptomaine one recovered, two died in five and six days after the inoculation.

Of the two pigs treated with the synthetical compound one died in thirty-nine days after the inoculation and fourteen days after the last check; the other one recovered entirely. Though this experiment is not conclusive, it certainly indicates that the pigs which had been treated offered considerable resistance to the disease, and that the synthetical compound is more effective than the ptomaine obtained from the culture liquids.

Had a somewhat larger quantity of the ptomaines been used for treatment, and the injections been made in smaller quantities, extending over a longer period of time, it is probable that all the treated animals would have recovered. At any rate we are sufficiently encouraged to continue the experiments. I may take occasion here to mention the valuable assistance rendered me by Dr. V. A. Moore in connection with the bacteriological work, autopsies, etc., and by Dr. Theobald Smith in allowing the use of the facilities of the bacteriological laboratory in his charge, and also the uniform kindly encouragement of Dr. Salmon, Chief of the Bureau.

SWINE PLAGUE.

While awaiting the results of further experiments upon hog cholera it was thought well to begin a study of the swine plague cultures, with the object of obtaining from them albuminoid and alkaloid poisons. The swine plague germ grows but slightly in the ordinary beef infusion culture. Dr. Moore, however, found that if instead of making a simple beef infusion a beef broth was prepared by boiling the meat the growth of the swine plague germ in this liquid was much more abundant. Alkaline media of this description were therefore used, 1,000 cubic centimeters in Erlenmeyer flasks being inoculated and kept in the incubator for two days at a temperature of 37° C. The growth of the germ was by this time very perceptible. The contents of the flasks proved to be uncontaminated. When opened a disagreeable, pungent odor was noticed.

After filtration about eight times its volume of absolute alcohol was added to the solution, and a considerable amount of a white flocculent precipitate was obtained. This, after settling, was filtered off, redissolved with water and again precipitated with absolute alcohol. The precipitate was thoroughly washed with absolute alcohol and dried over sulphuric acid in vacuo. A white translucent mass was thus obtained, with difficulty soluble in water and having properties of an albuminoid or proteid body. The filtrate from the albumose was neutralized with hydrocholoric acid evaporated to dryness, and the residue extracted with absolute alcohol. This alcohol extract gave alkaloidal reactions with mercuric chloride, phosphomolybdic acid, platinum chloride, etc., showing the presence of a ptomaine. The double platinum salt of this body I have prepared, but have not at this writing been able to make a satisfactory analysis of it. I have demonstrated, however, the existence in the culture liquids of the swine plague germ of a ptomaine and albumose. The name suplagatoxin may be given to the ptomaine (from the Greek ευζ, a hog, πληγή, plague, and τυξιχόν, poison), and suplagoalbumin to the al-

bumose. This would be distinctive from the *hog cholera* ptomaines. While purifying a larger quantity of these substances in order to make a closer study of them chemically, I thought it advisable to use the material at hand for making some experiments in the production of immunity in guinea pigs from swine plague by preventive treatment. Previous to this Dr. Moore had made a number of inoculations of guinea pigs with swine plague, which showed that one one-thousandth of a cubic centimeter of beef infusion peptone culture of swine plague one day old, was sufficient to kill a guinea pig in from twenty-four to forty-eight hours. Further, in order to see if the treatment which proved satisfactory for producing immunity against hog cholera might have any effect in retarding the disease of swine plague, two guinea pigs that had been submitted to the preventive treatment for hog cholera, but never exposed by inoculation, were inoculated with one one-thousandth of a cubic centimeter of beef infusion swine plague culture one day old. Both animals succumbed in forty-eight hours to the disease of swine plague. Two guinea pigs that had been subjected to the preventive treatment, then inoculated with hog cholera and recovered and were perfectly well, were inoculated with one one-thousandth of a cubic centimeter each of beef infusion peptone swine plague culture one day old. Both died, as was expected, in forty-eight hours. These experiments serve further to demonstrate, if proof is necessary, that the diseases of hog cholera and swine plague are distinct, and that an animal that has had the hog cholera and recovered is still susceptible as ever to the swine plague.

Experiment XII.—Two guinea pigs were selected, and on three successive days .0030 gram of swine plague albumose was injected subcutaneously in the thigh. About .0010 gram of substance was given at each injection. There was a slight swelling at the point of injection, which disappeared in four or five days and the animal appeared well. Two checks were now taken and the four inoculated with one one-thousandth of a cubic centimeter swine plague culture. The checks died, one in forty-eight hours and the other in thirty-six hours. The treated pigs appeared a little stupid for a day or two and then recovered entirely.

Experiment XIII.—Two guinea pigs were treated with a solution of the ptomaine extracted from the culture liquids. The injections were made subcutaneously in the inner side of thigh, the quantity of ptomaine used corresponding to about 15 cubic centimeters of the culture medium. There was a slight swelling and soreness at the point of injection, but otherwise the pigs appeared well. These, together with two checks, were inoculated with one one-thousandth of a cubic centimeter of swine plague culture. The checks died of swine plague. One of the treated animals died in thirty-six hours. The autopsy, however, showed but few marked characteristics of swine plague. At the point of inoculation there was a slight infiltration. Blood vessels in heart much injected; liver slightly reddened. Bladder distended with urine. Otherwise the organs were normal. Coverglass from spleen and liver showed *no swine plague germs*, but cultures from the liver showed that the swine plague germ was present. The other treated pig died five days after the checks, or eight days after the inoculation.

The ptomaine, therefore, produced resistance and a large dose would probably give immunity.

These few experiments, following the more extended ones upon hog cholera, prove conclusively that both these diseases can be prevented in guinea pigs by chemical inoculation. The experiments upon swine plague will be extended and a careful study made of the ptomaine and albumose produced by this germ, and their effect upon hogs.

Hankin holds that albumose is the one and principal factor in the production of immunity, and that the reason more results have not been secured in this direction is because the proper material has never been used. We think, however, that the albumose is only an intermediate product of the germs and the final and most fatal effect of the disease results from the ptomaines. At any rate the experiments upon hog cholera lead to the conclusion that while a mixture of the albumose and ptomaine seems to produce greater immunity than either substance alone, nevertheless when used separately they are of about equal value.

MISCELLANEOUS.

In addition to the study in connection with the disease just recorded the writer has given some little attention to the presence of tyrotoxicon in milk. In May a sample of milk from Maryland came into his hands which was supposed to have caused the sickness of a number of children. The symptoms as given indicated a possible tyrotoxicon poisoning. The milk was examined for the poison, but the latter could not be detected. Some months after this some cheese, which had produced sickness in this city, and two lots which had caused illness in Ohio, were received. In all three cases the questionable tyrotoxicon was blamed for the sickness. I could not, however, establish the presence of tyrotoxicon in any instance by the methods prescribed by Vaughan. This led me to repeat one of Vaughan's experiments, which should have given me considerable quantities of tyrotoxicon. Half a gallon of fresh normal milk was placed in a loosely stoppered glass jar and allowed to stand at the temperature of the room for three months during the summer. At the end of this time it was examined for tyrotoxicon, but the test failed to establish its presence. From this milk as well as from the samples of cheese Dr. Moore isolated several different germs, but other more important work has prevented a closer study of these and their products.

Our own experiments, supported by the negative results of a number of other chemists, force us to conclude that the toxic principles of poisonous cheese and milk have not been yet sufficiently studied, and that there is here a very important field for further investigations.

A number of other unimportant examinations and analyses have been made, but the facts established in regard to hog cholera and swine plague are the important results of our six months' work.

Tabulated experiments in producing immunity from hog cholera in guinea pigs.

No. of experiment.	Material used for treatment.	Hog cholera virus used for each animal.	No. of animals used.	No. of checks.	No. of days between inoculation with virus and death of checks.	Result in treated animal.
		Cc.				
I	Sucholotoxin	0.10	2	2	8 and 9	One died in 11 days; one recovered.
II	Sucholoalbumin	0.10	2	2	7	Died in 17 days; great resistance.
III	...do	0.10	3	2	8 and 10	Recovered; immunity.
IV	1. Sucholotoxins	0.10	2	....	....	Do.
	2. Sucholotoxin and albumin.	0.10	2	2	8 and 10	Do.
V	1. Sucholotoxin	0.10	2	....	....	
	2. Sucholotoxins	0.10	2	2	8 and 9	Do.
VI	Sucholotoxins	0.10	2	2 and 2 blanks.	8 and 9	Blanks died in 18 and 30 days; others not affected; immunity
VII	Pure chemical	0.10	3	2	8 and 9	Two died in 13 and 14 days; third recovered; immunity.
VIII	...do	0.10	2	2	6 and 7	Recovered; immunity.
IX	...do	0.10	4	2	8	One died in 13 days; others recovered; immunity.

EXPERIMENTS UPON HOGS (ESSEX GRADE).

X	Sucholotoxins	2	3	....	4 and 5	Two died in 5 days.
XI	Pure chemical	2	2	4	and 17 days; one recovered.	One in 36 days; two recovered; resistance.

EXPERIMENTS IN PRODUCING IMMUNITY FROM SWINE PLAGUE IN GUINEA PIGS.

XII	Suplagatoxin	$\frac{1}{1000}$	2	2	2 and 3	Recovered; immunity.
XIII	Suplagoalbumin	$\frac{1}{1000}$	2	2	2 and 3	One in 3 days, the other in 8 days.

REPORT OF THE CHEMIST.

WASHINGTON, D. C., *December* 22, 1890.

SIR: I have the honor to submit herewith a brief report of the work of my Division during the past year.

I am, respectfully,

H. W. WILEY,
Chemist.

Hon. J. M. RUSK,
Secretary.

STUDIES ON THE SEPARATION OF SUGAR FROM SORGHUM JUICES.

For many years attempts have been made by the division to secure a more perfect separation of the sugar from the non-sugars in sorghum juices. Extensive practical experiments were made in this direction at Fort Scott in 1886, in the practical application of the process of carbonatation.

This process consists in the addition to the mill or diffusion juices of large quantities of lime, from 1.5 per cent to 3 per cent of the weight of the juice, according to the amount of impurities present. The lime is then precipitated by blowing through the liquid a current of carbonic acid derived from a limekiln or coke furnace, or even from the chimneys of the boiler furnaces. The result of this process was entirely successful in respect of the yield of sugar, but on account of the blackening of the molasses, which was at that time a valuable by-product, it met with no favor from sorghum sugar manufacturers, but on the contrary was condemned by them as being unsuitable for the purpose.

Subsequently extensive laboratory experiments were made looking to the precipitation of the crystallizable sugar in the juices as sucrates of lime. The process employed in the Steffen method of separating sugar from beet-root molasses was the one tried for this purpose. While these experiments were successful in separating the crystallizable sugars in the form of a precipitate, they were not wholly so in securing a separation from the non-sugars, the greater part of which were also thrown down as lime compounds or carried down mechanically with the precipitated sugar. This process was, therefore, abandoned as not being practical.

The destruction of the reducing sugars or glucoses present by boiling with excess of quicklime was next tried. This process was entirely successful in so far as destroying the glucoses was concerned.

but it had no effect whatever upon the other carbohydrates, of an amorphous nature, present in the juices. Inasmuch as the glucoses exert the least unfavorable influence of the non-sugars present in the juices the process was at once seen to be inapplicable from a practical point of view. The experience of the Department, and of manufacturers of sugar, has shown that the reducing sugars known generally under the term of glucoses, exercise a much less influence in preventing the crystallization of the sugars than was formerly supposed. In fact, it is supposed that could all other disturbing influences be removed, the glucose might be unobjectionable in securing an almost complete crystallization of the sucrose present in the juices. It would furnish a mother liquor in which the crystallizable sugar would be highly insoluble and from which it would easily separate. Having abandoned, therefore, the methods of separation above noted, there remained to be studied some process which would separate as nearly as possible the gummy amorphous bodies from the juices without precipitating the sugar. The property of alcohol to produce precipitation in sorghum juice was made use of in the further study of this problem. On account, however, of the large amount of alcohol, which would be required to treat the juices in their natural state, or as they come from the diffusion battery, it was decided to apply the process at a later period of manufacture.

In order to carry out this idea the juices of sorghum were treated precisely in the manner in which they are ordinarily in a sugar factory. The natural acidity of the juices was carefully neutralized with lime and the temperature raised to the boiling point. The scums which were formed were carefully removed and the juice boiled in an open dish, until all greenish scums and coagulated matters were separated.

The inversion of sugar which takes place during the boiling, which lasts only a few minutes, was not noteworthy. The juices were next concentrated in vacuo until they reached a density of 45° to 50° Brix. After cooling, the sirup thus formed was mixed with an equal volume of 95 per cent alcohol, which was sufficient to produce a complete precipitation of the gummy amorphous matters. These matters were separated by passing through a filter press, forming a hard, firm cake, easily separated from the filter cloth. The filtered sirup was limpid and of an exceptionally pleasant flavor. Evaporating in vacuo after removal of the alcohol, it readily crystallized during evaporation, forming a massecuite of good grain and absolutely free from gum and capable of being treated most easily in a centrifugal.

From very poor sorghum juices from immature cane, having a purity of only 60, a most excellent article of massecuite and sugar was made by the above process.

In regard to the quantity of matters separated by alcohol, some determinations were made with the following results:

Percentage of gum secured by alcohol—	
Experiment 1	2.08
Experiment 2	1.88
Mean	1.98

The juices from which these separations were made contained about 16 per cent of solid matters; thus the percentage of matters secured by alcohol on the whole amount of solid matters present was 12.5

It is seen from the above data that from each 100 pounds of sorghum juice about 2 pounds of gum can be separated.

The difficulties which have been encountered in manufacturing sugar from sorghum juices have been chiefly due to the presence of these gums. Their removal, therefore, if it can be accomplished on a manufacturing basis, would at once place sorghum in a high rank as a sugar-producing plant.

The alcohol which is used in precipitation can be almost wholly recovered by subsequent distillation. Our experiments show that the total loss need not exceed 5 or, at most 10 per cent, of the quantity of alcohol used. One of the most encouraging and at the same time least expected results of the work has been the demonstration of the fact that the gum separated in the manner above described is completely fermentable, yielding almost one half its weight in alcohol. It thus appears that from the gums themselves a sufficient amount of alcohol may possibly be derived to supply the whole waste of alcohol which would take place in the process of manufacture. Any additional quantities of alcohol which might be needed could be easily obtained from the molasses after the extraction of all the crystallizable sugar. In other words, the process which has been demonstrated as thoroughly practical in the laboratory, so far as can be foreseen for the operation of an actual trial on a manufacturing scale, is capable of being conducted with economy, and a proper stock of alcohol once being provided the wastage therein in the process of manufacture could be wholly, or in great part at least, supplied by the refuse matter which otherwise would be a manufacturing waste.

Experiments were also made to determine the quantity of alcohol necessary to precipitate the total gum matters and also the strength of the alcohol required with the following results:

SORGHUM SIRUP, OF 44° BRIX AT 60° F.

On adding 15 cubic centimeters of 80 per cent alcohol, to 25 cubic centimeters of juice, the main part of the amorphous matters was precipitated.

Series of experiments.

[Comparison showing quantities of alcohol of 70, 80, and 90 per cent and of methyl alcohol (crude) necessary to precipitate 25 cubic centimeters of sirup, of 44° Brix at 60° F.]

	70 per cent.	80 per cent.	90 per cent.	Methyl alcohol.
	cc	*cc*	*cc*	*cc*
Chief precipitation of amorphous bodies	20	15	10	12
Total precipitation of those bodies	35	25	20	20

The portion of the amorphous bodies which is soluble in water becomes, in part, redissolved before filtration when precipitated with 70, and rather less so with 80 per cent alcohol.

The separation of the amorphous bodies can be attained on the manufacturing scale with 80 per cent alcohol by the application of 1 volume of alcohol to 1 volume of sirup of 44° Brix.

In order to illustrate the practical application of the method on a manufacturing scale in the manufacture of sorghum sugar the following theoretical data are given:

A normal sorghum juice may contain at 18° Brix 12 per cent of sugar; a normal sorghum sirup may contain at 44° Brix 29.33 per cent of sugar, which is equal to 29,330 pounds of sugar in 10,000 gallons of sirup. Of this, 29,330 pounds (from 7,280 to 13,000 pounds), or about an average of 10,000, has been obtained by the methods of manufacture in use.

By the use of alcohol for the removal of the amorphous bodies which prevent the crystallization of the sugar, the *minimum* per cent of sugar, which, after this process would be obtained, may be put at 80 per cent (87 per cent is usually computed from pure juices), or 23,464 pounds.

10,000 pounds, at 4 cents		$400
23,464 pounds, at 4 cents	$938	
Cost of alcohol lost in the work	84	
		854
Value of product, usual method	400	
Value of product, alcohol method	854	
A gain of		454

In this estimate the material from which the alcohol is made is not regarded as of any value, since it otherwise would be wasted. If the molasses be used as a source of alcohol, then the item for the cost thereof must be increased.

On account of the ease with which a heavy sirup can be preserved it has also been thought possible that during the manufacturing season the whole apparatus of the factory could be directed to making sirup alone which could be preserved and worked into sugar subsequently.

Inasmuch as it is highly important, in working a sorghum crop, to have it taken off in as short a time as possible, any scheme which will tend to simplify the operation during the harvesting season is worthy of consideration.

It is true that the storage of a whole crop of sirup would require considerable room and the cost of tanks or cellars in which it is to be held would be an item which could not be neglected. However, it must not be forgotten that by the storage system the machinery of the factory could be operated during a much longer period. For instance, it is well known that the harvesting operations and the manufacture of sugar must be chiefly conducted during the months of September and October. The manufacture of sirup into sugar, however, could be continued through the winter months, or if they were found too cold, the work could be safely left until the beginning of spring, when the factory could be again set in operation.

The whole of the apparatus for manufacturing the alcohol and for treating the sirup therewith could, therefore, be built on a much smaller scale than if it were necessary to treat the sirup as soon as it was manufactured during the months of September and October. With the sirup already made and stored in cisterns a very small force would be sufficient to convert the whole of it into sugar and at a very small expense. It would thus be possible for one factory to take care of a much larger crop of cane than it could possibly do were the whole of the manufacturing operations to be conducted at once.

The sirup as made and as it passes into cisterns could be subjected to the influence of sulphurous acid or some other anti-ferment which would be sufficient to preserve it perfectly from fermentation, even

if there were danger of such a decomposition without any antiseptic treatment.

The storage capacity of a factory which would work 20,000 tons of sorghum cane will be seen from a perusal of the following data: Assuming of 20,000 tons of chips and 10 per cent marc we have, 11,782,030 pounds sirup at 55° Brix=volume of 149,988 cubic feet, requiring a cistern 20 by 86.5 by 86.5 feet. At 75° Brix=8,640,380 pounds=volume of 100,213 cubic feet, requiring a cistern 20 by 75 by 75 feet.

In the event of boiling from 55° to 75° Brix, the water evaporated will be, on 20,000 tons of cane chips, 3,141,650 pounds, or 377,150 gallons. Basing calculations on Yaryan's figures, the coal consumption (at $8\frac{1}{2}$ pounds water per pound coal) in again evaporating from 55° to 75° Brix will be 369,600 pounds, using live steam altogether, as would be necessary in the contemplated division of the season. Hence the loss of coal occasioned by boiling to 75° Brix as a means of preserving and subsequent dilution would be 133,261 + 369,600 = 502,861÷2,240=225 tons, plus incidental losses, radiation, time, etc.

Placing the value of coal at $4 per ton, which is rather a high average, it is seen that the total additional expense, so far as fuel is concerned, involved in manufacturing the sugar after the harvesting of the crop, would be only about $900 a year, a very insignificant item when compared with the value of the time gained.

In order that this method of production of sugar may become possible, it will be necessary for the revenue laws to be changed so as to allow the preparation of the alcohol used in the process to be carried on without tax. This could be easily done without any danger of defrauding the revenue. The alcohol could be made under bond, given by the sugar manufacturer, that it should be used only for the purpose of separating the gummy matters from the sorghum juice, and should in no case enter commerce for any purpose whatever. In making this alcohol the manufacturer should be allowed to erect such apparatus as may be necessary, and this apparatus could be under the direct inspection of revenue officers in order that they might be able to see that the conditions of the bond were faithfully carried out.

It is earnestly recommended that the revenue laws be so amended as to allow a trial of this process by the sorghum-sugar makers of the country. If this can not be done without a further illustration, the law, at least, should be so adjusted as to permit the Department to make an experiment on a small scale with this method in connection with the work which it is now doing in the experimental station for the improvement of sorghum cane and the manufacture of sugar therefrom.

It is important also that the Department be empowered, by a special grant, to carry out these experiments in a practical way. From the best estimates which are now at my disposal I should say that a grant of $25,000 would be entirely sufficient to subject this process to an experimental trial. The magnitude of the interest involved is so great that it is hoped that no objection will be made to this experiment.

Not only is the increase in the output of sugar from sorghum cane to be taken into consideration, but also the improvement in the quality of the product. The sugar will be of a finer grade and much more easily separated from the molasses. The molasses instead of being, as it is now, a waste product scarcely marketable, and in many cases only

fit for cattle food, will be suitable for table use and especially for mixing, in case compound sirups are desired. The flavor of both the sugar and the molasses produced is of the finest quality and of such a nature as to render it difficult to believe that it could have been made from sorghum, which, under ordinary circumstances, affords a molasses which is totally unpalatable.

This process having been outlined above in such a way as to indicate its true character, it is hoped it may be given to the sugar manufacturers of the country without interference from any patents which may be attempted to secure its provisions for private benefit. As our patent laws now stand any process which has not been in use for two years may be covered by letters patent, but in this case it must be distinctly proved that the inventor is, as he claims in his application, the true discoverer of the process. This process having been discovered and operated by the Chemical Division of this Department, is unpatentable, except by the Department, for the common use of the people.

THE COMPOSITION OF THE BODIES PRECIPITATED BY ALCOHOL FROM SORGHUM SIRUPS.

The existence of starch and allied bodies in sorghum juices has long been a matter of demonstration. It was deemed desirable, however, in connection with the practical work of separating from sorghum juices the mucilaginous and dismorphous bodies present to inquire more particularly into their nature. As has already been indicated, the chief melassigenic or molasses-forming properties of the non-sugars present in sorghum juices must be attributed to the gums, mucilaginous bodies, and difficultly crystallizable carbohydrates present therein. The percentage of alkaline salts in the ash of the sorghum is so small compared with that of the ash in beets as to reduce the molasses-forming properties of the salts of the ash to the lowest possible degree. Quantitative determination of the amount of bodies precipitated by alcohol from the normal expressed juice of sorghum cane shows that about 2 per cent of the total weight of the juice of the cane belong to this class of bodies. The precipitation was made in juices in which a portion of the albuminous matter, together with the chlorophyll present, had been removed by coagulation with heat and careful skimming. This quantity of precipitate may therefore be regarded as that which would be retained in the sorghum juices during the process of manufacture, and finally appear in the massecuites and molasses.

An account of the details of the work which has been done on these bodies would be of interest only to professional chemists and it is therefore omitted. It was found that they were composed chiefly of mucilages and gums, together with certain nitrogenous bodies and difficultly crystallizable carbohydrates, related to the starch series, and including some starch.

A full description of this work will be found in Bulletin No. 29. The work outlined above was done in co-operation with Mr. Walter Maxwell.

CHEMICAL CONTROL OF SORGHUM SUGAR FACTORIES.

The Department made no direct experiments during the season of 1890 in the manufacture of sorghum sugar. The work done was confined solely to chemical supervision of the processes of manufac-

ture. To secure as wide an experience as possible in this direction chemists were detailed from the Department for the factories at Fort Scott, Topeka, Conway Springs, Attica, and Medicine Lodge, Kansas. A summary of the chemical work done, together with such data as were accessible, will be found following:

ATTICA.

Work at this station was started on the 19th of September and and continued, at intervals, until October 25. On this latter date one of the lower doors of the diffusion battery cell was broken and it was not thought worth while to repair the battery for the remaining portion of the crop. A very small quantity of cane remained unworked. The many difficulties encountered in the working of this house would render it unjust to make the results a test of the possibilities of manufacture of sorghum sugar.

The cane crop was much shortened by a severe drought, which set in about a month after the planting and continued unbroken for sixty days. The yield of cane per acre was reduced from 12 to 15 tons of last year to 5 and even 3 tons per acre. Chinch-bugs were also quite numerous and did considerable damage. Hot winds, the most dreaded enemy of the farmer in that region, were prevalent during the continuation of the drought. Not only was the crop shortened by the continued dry weather, but also the supply of water for the factory was inadequate, the small stream upon which dependence was placed having been completely dried up. Under these conditions the factory was not operated continuously, but only during the day.

The necessity of better cultivation of the cane fields was fully manifested in a number of instances. The fields which received poor cultivation were almost devoid of crops, while those which received the best cultivation yielded a fair crop in spite of the hot and dry weather. It was not until October 12 that there were sufficient rains to insure an ample supply of water for operating the factory, but at that time it was not possible to get enough cane to operate the factory.

The seed which had been received from the Department of Agriculture produced, in all cases, the best cane grown in the locality, averaging 4 and 5 tons per acre above all other varieties. The loss of a large quantity of sugar in the battery was owing to the heaters which leaked very badly. Another serious loss occurred between the clarifiers and double effects. This was due to the inability of the double effects to evaporate the juice extracted so that some of the thin juice was left sometimes as long as 12 hours before being concentrated and, of course, fermentation took place.

Special attention was given to studying the characteristics of the cane showing that certain physical properties are associated with high percentages of sugar. By studying these properties carefully, it is possible for every farmer to go into his field and be able to determine certainly whether his cane is ripe or not. The most striking of these properties is found in the last joint of the cane bearing the seed head. By stripping the cane of its covering a yellow coloration will be observed extending more or less along the length of the joint as the cane nears maturity. By the extent of this coloration one is able to select the very best or the very poorest canes in the field almost as accurately as though tested by a polariscope. It is found that the cane which has the highest sucrose, lowest glucose and highest purity

has this coloration extending one-half the length of the joint. Should it be found to extend the full length, it shows that the cane has already commenced to deteriorate. On the other hand should no coloration be visible, it shows that the cane is not yet mature. These observations have extended over one season of rather remarkable characteristics and hence they may not prove equally applicable to a crop grown in a season with the ordinary amount of rainfall.

The analyses of the sorghum at Attica were commenced on the 9th of September and continued until the 24th of October. During this period one hundred and fifteen average samples, as taken from the field, were analyzed with the following mean results:

In the juice.

Per cent sucrose	14.26
Per cent reducing sugars or glucose	1.53
Purity coefficient	71.91
Maximum per cent sucrose	17.95
Minimum per cent sucrose	5.85
Maximum per cent reducing sugars or glucose	3.43
Minimum per cent reducing sugars or glucose	.55
Maximum purity of juice	90.80
Minimum purity of juice	35.83

Between the dates of October 6 and 9 the purities of the juices were remarkably high, averaging about 85, and the percentages of sucrose therein were almost 16, showing that at that season the cane was in the best condition for manufacture. The analyses, however, for the whole season show a cane well suited for the manufacture of sugar, and which should yield, if all the sugar could be obtained, except the quantity which would naturally stay in the molasses, quite 200 pounds to the ton of clean cane.

Many of the farmers found the growing of cane profitable, while in other cases quite a number failed to make any profit or cultivated the cane at a loss. The figures representing one farmer's account with the company will illustrate what may be secured in a poor season in the growing of sorghum cane.

Total weight of cane grown	pounds	357,735
Total weight of seed grown	do	74,915
Amount received for the cane		$357.74
Amount received for the seed		$35.18
Total receipts for the crop		$392.92

Against this sum the following expenses are to be charged:

Cost of planting	$37.50
Cost of cultivating	50.00
Cost of harvesting and delivering to mill	175.00
Total cost, as charged	262.50

Leaving a net profit of $130.42. The number of acres cultivated in this crop was 30, and on the numbers given above the profit per acre would be $4.35. It will be noticed in the above that no charge has been made for the rent of the land, which is, of course, a legitimate expense which must come out of the calculated profit per acre. The value of the land upon which this cane was grown is not known to me, but, judging from the average value of land in that locality, it may safely be put at $20 to $25 per acre; hence a deduction of $2 per acre should be made for rent of land, leaving a profit per acre of only $2.35 instead of $4.35.

The analyses of the samples of chips taken from the shredders as they pass to enter the battery, which samples give a fair estimate of the quality of the chips entering the diffusers, show, as is usual in all cases, a less saccharine strength than average samples of field cane. The reason of this difference is twofold. In the first place the samples of the first chips must of necessity give a better representation of the crop than any possible selection of single stalks or number of stalks of cane can give. In the second place, in spite of the best clarifying apparatus, particles of the blades and sheaths enter the shredder with the pieces of cane, and the juices of these are expressed afterward and mingle with the juices of the cane. Forty samples of these chips were analyzed during the season with the following mean results:

In the juice.

Sucrose....per cent..	12.56
Glucose....do....	1.99
Purity....	63.20

Thirty-two samples of the diffusion juices, representing the mean composition of the juices during the season, were subjected to analysis with the following mean results:

Sucrose....per cent..	7.99
Glucose....do....	1.20
Purity....	66.48

Thirty-two samples of the exhausted chips, representing the mean composition of the whole mass of exhausted chips during the season, were analyzed, the analyses showing that they contained 0.60 per cent of sucrose.

Twenty analyses of the filtered and clarified juices, representing the mean composition of the clarified juices of the whole season, showed the following average constitution:

Sucrose....per cent..	8.11
Glucose....do ...	1.01
Purity....	67.46

Seventeen analyses of the sirups before entering the strike pan, representing the average composition of the whole sirup worked during the season, gave the following mean results:

Sucrose....per cent..	32.91
Glucose....do....	7.12
Purity....	63.11

Eight analyses of the massecuites, representing the average composition of the whole mass produced during the season, gave the following mean results:

Sucrose....per cent..	54.89
Glucose....do....	12.32
Purity....	62.35

Five analyses of the second massecuites, boiled from the first molasses after the separation of the first mass of crystals, showed the following mean composition:

Sucrose....per cent..	47.52
Glucose....do....	12.77
Purity....	55.65

The total amount of field cane purchased during the season was 1,305.3 tons. After cleaning, the total weight of cane which entered the diffusion battery was 900.2 tons.

The theoretical percentage of sugar in the clean cane, as calculated from the juice of the chips, was 238.6 pounds.

The quantity of sugar obtained in a merchantable form can not be accurately known until the official report of the State Inspector is known. The quantity, however, in proportion to the total amount present was extremely small and probably did not exceed 75 or 80 pounds per ton.

The enormous losses, therefore, in manufacturing sorgum sugar which have always been noticed in practice are illustrated in a very emphatic manner by the results of the season's work at Attica. Such losses are due to the natural wastage during the process of manufacture, and are, of course, raised to an unusual degree where lack of skill exists in the manipulation of the factory. The chief losses, however, as heretofore, have been due to the character of the juice itself, presenting in its constitution peculiar difficulties in the separation of the crystallizable sugar present.

OPERATIONS OF THE TOPEKA FACTORY.

The Topeka Sugar Factory, which was destroyed by fire last year, was rebuilt during the present season and operated for the manufacture of sugar.

Difficulties of various kinds, but in no wise inherent to the process of manufacture, caused delays in the operations of the factory and rendered its work expensive. The supply of steam was not sufficient for the full working extent of the rest of the machinery, and the multiple effect pans were provided with very low domes, which rendered successful boiling difficult. Moreover, the fuel employed was of particularly bad quality. The pumping arrangements were found inadequate to provide an abundant supply of water.

The crop of cane was somewhat later in maturing than usual, due to the autumnal rains following a very dry summer. The crop ripened in a very irregular way, thus causing to be delivered to the factory canes in various stages of maturity. The amber cane reached its maximum maturity about the middle of September, and the orange cane about the middle of October.

The battery work was extremely irregular, the percentages of dilution ranging from 8 to 14, and the percentages of extraction of sugar from 80 to 95 per cent. The percentages of sucrose in the exhausted chips vary from 0.05 per cent to 2 per cent; the number of diffusion cells worked daily varied from twenty-three to one hundred and four, and the loss of time daily by stoppages was from two to fourteen hours. Under such irregular conditions of work, due generally to the causes already mentioned, it is not strange that attempts at the successful manufacture of sugar were fruitless.

Cane contracted for by the company was	acres..	1,200
Cane delivered to the mill was	do...	1,000
Cane delivered	tons..	6,412
Yield of cane per acre	do...	6.41
Total amount of sugar made	pounds..	278,687
Yield of sugar, per ton of field cane	do...	43.57

By the term "field cane" is meant the cane with its blades and tops. The average amount of clean chips afforded by such cane is 75 per cent. of the total weight. The amount of clean cane, therefore, entering the battery under this estimate was 4,809 tons. The yield of sugar, per ton of clean cane chips, was therefore nearly 58 pounds.

The sampling of the chips entering the battery was made in the usual way so as to secure a fair average of the cane worked. The analyses of these samples were commenced on the 10th of September and were continued until the close of the house on the 8th of November.

Forty-seven samples of fresh chips were analyzed with the following mean results:

In the juice.

Total solids .... per cent..	15.97
Sucrose .... do....	10.15
Glucose .... do....	2.14
Purity	63.56

A mere glance at these figures will show that the cane was in a very poor condition for sugar making purposes. This was due to the causes already stated, namely, the autumnal rains which prevented the cane from properly maturing, and the fact that the fields were planted with mixed seeds so that some of the cane was mature at a much earlier period, and doubtless the principal cause was imperfect cultivation. The poor character of the chips for sugar making purposes is illustrated in a striking way by comparing the analyses of them with the analyses of chips from cane in other parts of the State. Considering the character of the material worked, the yield per ton must be considered as quite satisfactory.

Twenty-seven analyses of the exhausted chips were made, showing a mean percentage of sugar therein of 1.77. This result shows very poor battery work. A mean percentage of sugar in the exhausted chips of more than 0.5 per cent shows some grave defect in the method of working. This defect is usually due to imperfect chips; the shredders become dull, allowing large pieces of cane to go through unshredded, the internal portions of which are protected from the diffusion process. With chips properly prepared and the temperature of the battery properly regulated there is no difficulty whatever in securing extraction which will leave 0.5 per cent or less of sugar in the bagasse.

Fifty analyses of average samples of the diffusion juice were made with the following mean results:

Total solids........ per cent..	12.99
Sucrose .... do....	8.54
Glucose .... do....	1.67
Purity	67.39

Forty-eight analyses of the clarified juices were made with the following mean results:

Total solids .... per cent..	13.23
Sucrose .... do....	8.91
Glucose .... do....	1.57
Purity........	68.49

Twenty-five analyses of the sirups entering the vacuum pan were made with the following mean results:

Total solids........ per cent..	38.58
Sucrose .... do....	25.24
Glucose .... do....	3.94
Purity........	64.69

For convenience of reference the work of the factory was divided into three periods, namely: First period from September 10 to 20; second period from September 20 to October 15; third period from

October 15 to October 30, not including the last two days of the run in November. The mean data for the three periods are as follows:

Fresh chip juice.

	First period.	Second period.	Third period.
Total solids........per cent..	16.58	16.09	16.67
Sucrose..............do.....	10.02	10.38	11.18
Glucose..............do.....	2.68	1.81	1.84
Solids not sugar......do.....	3.94	3.90	3.65
Glucose ratio................	26.15	17.44	16.45
Purity coefficient...........	60.43	64.51	67.67

The means for the whole season, excluding the November run, are:

Total solids..............................per cent..	16.32
Sucrose......................................do....	10.54
Glucose......................................do....	1.92
Solids not sugar.............................do....	3.86
Glucose ratio..	18.22
Purity coefficient...................................	64.56

The constant improvement of the material entering the battery from the beginning to the end of the season is strikingly illustrated by the above figures. We find the same fact true of sorghum that is illustrated in sugar cane, that the longer the season for manufacturing can be delayed the richer the material in sugar will become. With an average of 10.5 per cent sugar in the juice and 9.45 per cent sugar in the cane, the total amount of sucrose in a ton of clean chips is 189 pounds and the amount obtained in a merchantable form of the raw sugar, as indicated above, is 58 pounds, which would amount to about 55 pounds of pure sugar.

The results illustrate the striking loss of sucrose in the juice in sorghum sugar manufacture heretofore carried on, viz., a loss of 134 pounds of sucrose for each ton of clean chips worked. This loss, as has already been pointed out repeatedly, is due to the pernicious effects of the reducing sugars and organic matters not sugars present in the juice, such organic matters, as shown by our work during the present year, having amounted to 3.86 per cent. It is perfectly safe to say that the total loss of sugar in the molasses was almost exclusively due to the presence of these gummy matters in the juice. It is evident at once that the financial success of sorghum sugar manufacture must follow some method of work which would elminate these sources of loss.

CONWAY SPRINGS.

The large factory at Conway Springs having been abandoned after two seasons of unsuccessful operation, the only work which was done at that place consisted in an attempt to make sugar in a small way by milling and open evaporation.

The results, easily predicted, only serve as another illustration of the futility of attempting sorghum sugar manufacture without any of the appliances or conditions necessary to success.

The promoters of the enterprise, however, desiring to have some chemical work done, a chemist was employed for the season. Chemical work was commenced on the 25th of September, and practically

concluded on the 25th of October. During this time the mill was in operation only at irregular intervals, and there was found a total lack of proper preparation. The whole process, in fact, was characterized by unscientific methods.

The cane showed a great deterioration from the quality produced in the preceding years, but the cause of this inferiority is not clearly evident.

Forty-two analyses of samples of cane from the field showed in the juice the following percentages:

Total solids	per cent..	18.1
Sucrose	do....	10.4
Glucose	do....	4.4
Purity		57.5

Twenty-four samples of juices taken from the mill during the period it was in operation showed the following numbers:

Total solids	per cent..	16.5
Sucrose	do....	9.5
Glucose	do....	4.5
Purity	do....	57.6

The utter unfitness of these canes for sugar making purposes is at once evident. As a natural result of the poor quality of the raw material and inadequate methods of manufacture pursued, no sugar at all was produced, and even the molasses made was of a very inferior quality.

RESULTS AT FORT SCOTT.

The general operations of the Parkinson Sugar Company, and the results obtained, are set forth in the following report of the manager, Prof. J. C. Hart:

The spring of 1890 was all that could be desired by the sorghum growers. The winter had been mild, with just enough rain to make the ground work well, and the larger part of our cane ground was plowed before the first of March. The first planting was done March 28, and this cane did remarkably well, ripening the first week in August. The weather continued favorable until July, when it became very hot and no rain fell for several weeks. Cane was forced to head prematurely, especially on high ground and thin soil. In September there were heavy rains, and canes that had ripened early threw out from one to four new heads, which grew much taller than the original stalk and occasioned loss of sugar. The September rains brought on the late cane, so that the tonnage was good, though the quality was not what it would have heen had the season been uniform. Work was begun in the sugar house August 19 and continued till November 1, a total of sixty-nine working days.

Acres of cane	1,100
Tons of cane	7,575
Tons for sugar	7,100
Pounds sugar	356,000
Gallons sirup and molasses	117,000

The chemist's report has not yet been made and I can not give the quality of the cane as compared with last season, though the density will average somewhat higher this year, and purity of diffusion juice about the same as last; that is, 62. Diffusion juice to September 15, from Amber, only shows a density of 11.35; September 15 to October 1, part Amber and part Orange, 13; and for October, all Orange, the density was 14.2. The amount drawn in October was 50 litres less than in September, but allowing for that the yield from Orange was better than from Amber. I received from the Department several selected seed heads which were grown at Sterling in 1889. I give the analyses of a few varieties as compared with last season:

Amber, 235; average seven analyses, 1889, sucrose, 13.51; Amber, 235; average twelve analyses, 1890, sucrose, 13.1; Brix, 17.3.

Maximum density August 16, 1890, 18.5; maximum purity August 14, 1890, 80.6; maximum sucrose August 25, 1890, 14.1.

Stalks small, but the variety is valuable for its high sucrose and early maturity. Seed heads of all tested stalks saved, together with several bunches not tested.

Cross of Amber and Link's Hybrid, 161; average nine analyses, 1889, sucrose, 15. Cross of Amber and Link's Hybrid, 161; average nine analyses, 1890, Brix, 17.7; sucrose, 12.8. First ripe canes, September 5; 17.7 Brix; 12.9 sucrose. Maximum sucrose, 13.9 October 7. A good variety, but rather slender and falls easily.

Cross of Amber and Orange, 293; average five analyses, sucrose 17.38. Cross of Amber and Orange, 293; average seventeen analyses, Brix 18.71; sucrose 14.21.

First test, September 5, Brix 18.6, sucrose 15, was ready for working ten days earlier and is valuable as an early cane, as it is stockey, stands up well, and holds its purity much better than Amber. On October 14 it showed Brix 21.44, sucrose 15.6, and October 24 Brix 18.9, sucrose 12.3.

India and Orange, 320; average ten analyses, 1889, 15.97 sucrose; average six analyses, October 1890, Brix 18.62, sucrose 14.43. This is a heavy cane and will be valuable.

Folger's Early, 205; 1889, Brix 19; no sucrose given. Twelve analyses, 1890; Brix 18.6, sucrose 13.78. First analysis, August 25; was ripe a week earlier and is very valuable as an early variety, being tall and strong.

Black African, Undendebule, 254, and Honduras gave good results, but need further trial to determine their value for this locality.

Beet seed was obtained from the Oxnard Beet Sugar Company and several plots were planted as soon as the seed arrived, which was May 20.

A very poor stand was obtained owing to heavy rains immediately following the planting. Web worms destroyed a large part of the crop. Twelve analyses in October gave Brix 16.05, sucrose 13. Beets taken from the field December 12 tested 17.76 Brix, 15.67 sucrose.

OPERATIONS AT MEDICINE LODGE.

Manufacturing operations at Medicine Lodge commenced on the 18th of August and continued until the end of October. The machinery in use last year had been thoroughly overhauled and placed in excellent working order. No delays, of any consequence, were experienced in working the apparatus, and, for the first time in the history of the manufacture of sorghum sugar, the losses due to delays were reduced to a minimum.

The crop of sorghum cane was grown in a season of great drought, which prevented the corn crop from maturing. The evil effects of the drought were felt also on the cane, but in spite of it a crop of considerable magnitude was produced. On the 25th of August the long period of drought and hot winds was broken by copious rains and from that time until the end of the manufacturing season frequent rains fell. The cane in the fields readily ripened after the rains and many fields which were considered worthless redeemed themselves and produced considerable quantities of merchantable cane. The high red loam of the uplands produced a better crop than the low bottom lands, both in quantity and quality. In addition to this, the first frost affected only the bottom lands and the cane on the uplands had fully three weeks longer season on this account than the cane on the lowlands.

Interesting observations were made on the effect of the drought upon the different varieties of cane. The Early Orange and Link's Hybrid gave about the same tonnage under similar conditions and also had about the same content of sugar. If there was any advantage it was in favor of the Link's Hybrid. The varieties Undendebule and Honey Dew gave disappointing results; the tonnage was light sucrose and purity low, and the cane rapidly deteriorated after a light frost. A new variety of cane, which may be called, provisionally Medicine Lodge Orange, made a splendid showing. The seed head

of this variety is small, compact, and does not spread or open on reaching maturity. The stalk is perfectly formed and resembles very nearly that of the Early Orange, from which it can be distinguished only by its earlier ripening. It contains a high percentage of sucrose, low glucose, and endures a dry season remarkably well. It ripens in from 90 to 100 days from the time of planting. It is also hardy and does not deteriorate rapidly after frosts.

The Black African was one of the best varieties tested during the season. This variety not only has high sucrose and purity, and low glucose, but is a large cane and endures drought well. Its tonnage was nearly double that of the other varieties and it maintained its high percentage of sucrose longer than any other variety tried.

As a result of the agricultural experience of the season, it seems best to plant only the early maturing varieties on the lowlands while the late maturing varieties should be planted on the uplands.

The results of the mean analyses of the cane chips entering the battery for the season show the following numbers:

In the juice.

Total solids........per cent..	18.29
Sucrose........do....	12.62
Glucose........do....	2.24
Purity........	69.86

The exhausted chips contained 0.81 per cent sucrose; the mean polarization of the first sugars made was 91.8 and of the second sugars made 91.2. The mean percentage of sugar in the cane extracted for the whole season was 93.6. The mean percentage of marc or fiber in the cane was 12.2.

In regard to the analyses of the Link's Hybrid variety, the means of four hundred and thirteen analyses show the following numbers:

In the juice.

Total solids........per cent..	19.72
Sucrose........do....	13.59
Glucose........do....	1.85
Purity........	70.00

Four hundred and sixty-two analyses of the Early Orange during the season show the following data:

In the juice.

Total solids........per cent..	20.20
Sucrose........do....	13.20
Glucose........do....	1.96
Purity........	65.24

Eighty-seven analyses of the Medicine Lodge Orange gave the following data:

In the juice.

Total solids........per cent..	20.18
Sucrose........do....	15.60
Glucose........do....	1.87
Purity........	78.82

Thirteen analyses of the Undendebule gave the following data:

In the juice.

Total solids........per cent..	18.80
Sucrose........do....	12.45
Purity........	65.93

Thirteen analyses of Honey Dew showed for the season the following results:

In the juice.

Total solids	per cent..	17.42
Sucrose	do....	11.43
Glucose	do....	2.98
Purity		64.19

Following are the mean analyses of the Black African for the month of November:

In the juice.

Total solids	per cent..	19.88
Sucrose	do....	13.90
Glucose	do....	2.04
Purity		71.98

Samples of cane were taken from 1,973 loads brought to the factory and examined with the following mean results:

In the juice.

Totol solids	per cent..	19.31
Sucrose	do....	13.30
Purity		69.14

Nine hundred and forty-one miscellaneous analyses of the cane from farmers in different parts of the county were made with the following mean results:

In the juice.

Total solids	per cent..	19.83
Sucrose	do.....	15.12
Glucose	do.....	2.21
Purity		71.01

The summary of the season's work will give a fair idea of what was accomplished:

Working days		35
Clean cane worked	tons..	3,957
First sugar obtained, per ton of clean cane	pounds...	101.1
Second sugar obtained, per ton of clean cane	do	22.5
Total yield, per ton of clean cane	do.....	123.6
Sugar obtained, based on total amount in cane, per ct.		51.4
Molasses made, per ton of clean cane	galls..	13.8
Total weight of sugar made	pounds..	489,357

DIFFICULTY OF MAKING SORGHUM SUGAR IN SMALL QUANTITIES.

It is to be regretted that certain hallucinations seem to constantly follow the development of the sorghum sugar industry. This Department has pointed out repeatedly the insurmountable difficulties attending the production of sorghum sugar in a small way and with crude apparatus and unscientific methods. The record of the past season at the various points where the Department was represented by its chemists tends to confirm the views in this regard so often expressed heretofore. Thus the development of this industry has had to contend not only with natural difficulties but with the discouragement attending numerous failures, although such failures were altogether due to causes which would have resulted as disastrously in connection with any other industry. In some cases, as in the experiment at Conway Springs for instance, the promoters testified to the honesty of their convictions by investing their own private funds without any public aid. While such an investment is certain to be followed by financial loss, what is far worse from a

public point of view, it will prejudice the community against the whole business, and prevent people from viewing in the proper light processes which really give promise of success.

It is evidently the duty of the Department to caution farmers, and to reiterate what has been so often stated, that with our present knowledge, and with the present degree of development of the sorghum cane, it is an utter impossibility to produce sugar profitably in a small way and without an ample and suitable equipment. That a good article of table sirup can be made with moderate facilities, and profitably, has long been known, and I conceive it to be the duty of the Department to encourage such work as that, and to discourage in every possible way attempts to make sugar under conditions and with apparatus suitable only for the manufacture of sirup. It is unfortunate that in spite of the unsatisfactory results a glowing report has been published of the season's work at Conway Springs, and still more unfortunate to find it published in an influential sugar journal without any comment whatever, thus lending to it an air of authority which it is feared may prove to some extent injurious.

If the alcohol method of treating sirups should prove to be a success, it might then be profitable in some localities to make a thick sirup in some small way for delivery to a central factory. Such a method might be advisable in cases where cane would otherwise have to be hauled a long distance to the central factory. These possibilities, however, are still in the future, and do not call for discussion at the present time.

CULTURE EXPERIMENTS AT STERLING.

The experimental work of the Department at Sterling was continued during the year 1890 on the same general lines of work as those followed in previous years. The whole year was unexceptionally dry. Planting was commenced on the 1st of May and finished on the 23d. Before the last of the planting was completed the ground had become so dry that the seed of the last plots planted remained for a long time in the ground without germinating. Not only did this cause a late maturity of the canes whose germination had been deferred, but also produced an uneven ripening of all the plots thus affected. Some of the seed which germinated as soon as planted produced canes ripening long before those from the delayed germination. Planting was done by hand and the seed covered by a hoe.

The land varied widely in quality, from fairly fertile spots to barren sandy knolls. Much of it had not been in cultivation for several years, and part of it had been in sorghum for many years. In addition to these disadvantages of soil and season, a severe frost on the 13th of September killed all the cane in the greater part of the experimental plots. This frost was almost a month earlier than the average of the locality. After the frost the working force of the station was brought down two-thirds and the total amount of work done was probably only about one-third what it would have been had the frost been delayed for another month. In many of the plots, however, the analyses were kept up for some time after the frost, selecting for this purpose stalks here and there which still showed green leaves. In some cases the canes which had been frostbitten rapidly deteriorated, and in no case did they improve, but in some instances they remained quite stationary in quality for a considerable

length of time. It was noticed in many cases that the canes retained their sugar content in quite a constant manner for five weeks after the frost had destroyed nearly all the leaves. The comparison of varieties under such circumstances must be more or less unreliable, and hence the analytical work of the station is not as indicative in its results as it was during previous years. The experimental plots occupied in all about 165 acres. The different plots were sowed in plots 25 feet wide, leaving about 25 feet between them to avoid mixing. This is probably not a sufficient distance, but on account of the large number of plots with which it was desired to experiment, it was not possible to plant them farther apart without extending to undue proportions the total area under cultivation.

One hundred and twenty-seven plots were planted with seeds from foreign countries, received through the Department of State in response to a request from the Department of Agriculture. Two hundred plots were planted with seed selected at the station last year by the analyses of single canes. Twenty-six plots were planted from seeds which were received from Dr. Peter Collier, director of the Experiment Station at Geneva, New York. Four hundred and fifty-five plots were planted with seeds from canes which showed evidences of being crosses of Link's Hybrid and Early Amber. Each of these plots was planted with seed from a single head and were grown in the hope of finding among them canes showing new and desirable qualities. Some of these plots gave remarkably fine canes of new types having from 14 to 16 per cent of sugar, while others were inferior in every respect to each of the parent forms. In all, twenty of these plots seemed sufficiently good to justify preservation and the seed was saved from them for future growth.

All the one hundred and fifty-three plots planted with foreign seed, including two varieties, unnamed, from Australia, produced fine canes of good quality.

Of the various crosses first selected in 1888, planted in 1889 and again in 1890, several having proved unusually good during the three years of trial, will be retained for further experiment. Most of these new varieties are now well established and uniform in their characteristics, but there are some which still show a persistent tendency to reversion. Special data which were obtained with the Colman cane and with numbers 160, 161, and 289, are of such a character as to fully justify the whole of the labor which has been expended by the Department at the station in the development of new varieties from crosses. These four varieties possess qualities for sugar making superior to all other known varieties of sorghum, and these characteristics have been secured by careful attention to scientific principles of selection and propagation which have been practiced at Sterling from the first. There is still opportunity for a large amount of judicious work in selecting from varying seedling canes, having juices of greater purity, for there are wide differences in this respect, and it will require several years more to develope among them characteristics sufficiently uniform to justify their selection as sugar-producing plants.

Many varieties which had given good results in previous years were planted in a large number of plots in different soils and at various times in order to determine their average value. The stand of cane was almost perfect except where destroyed by drift sand. The seeds selected at the station have often shown a vitality of 98 per cent at the time of planting. With such seed and due care in sowing it

would seem possible, so far as the experimental work has shown, to have a good stand of cane without either thinning or replanting. Neither was done this year. No fertilizers were used and no suckers nor offshoots removed. With the exception of small plots, which were hoed twice, the cultivation was such as any careful farmer would give his crop. In such hot and dry seasons as this was there seems no doubt that deep and close cultivation after the canes are large injures them. On the other hand, frequent and shallow cultivation, even after the canes are well grown, favor their development on principles of soil physics which are well understood.

The yield of cane per acre was not nearly so large this year as in the season of 1889, but was better than in 1888. In general all the varieties which have been subjected to careful selection showed a larger percentage of available sugar in the juice than any other of the previous years. Another point mentioned is that the character of the juices in the sorghum appears to vary less with the season than does the yield of cane. As an instance of this characteristic, developed by the experiments, we may cite the variety of cane known as 161. In 1889 seventeen analyses of this variety were made, extending from September 4 to October 26. The average percentages given were as follows:

Sucrose	per cent..	13.24
Reducing sugar	do....	.45
Solids not sugar	do....	3.56
Purity	do....	76.75

In 1890 twelve analyses of the same variety were made, extending from August 12 to October 21, showing the following mean percentages:

Sucrose	per cent..	14.81
Glucose	do....	.69
Solids not sugar	do....	3.77
Purity	do....	76.85

One of the most marked effects of selection, as practiced at Sterling, has been manifested in the earlier maturing of the cane. Some of the different varieties grown during the past year ripened two or three weeks earlier than was the case with the progeny of similar but unselected seed. Judging from the work already done sorghum cane may be developed in any particular direction by continuous selection of the qualities desired. If, for instance, a high sugar content be desirable, by continued selection for high sugar only, this property of the cane may be made persistent, and the same is true of low glucose or low non-sugars.

The work of the station during the year comprised 2,500 analyses of average samples of sorghum, in large quantities, taken from the plots, and about 9,000 polarizations of the juices of single selected canes. Twelve thousand selected seed heads from the best varieties were wrapped separately and descriptive tags attached to them for the purpose of continuing the work, not only at the station, but by distributing these seed heads to those interested in such researches. By planting a single seed head and saving all the seed produced therefrom a very large field of cane can be produced from each of these 12,000 heads in 1892. In other words, from these 12,000 selections it would be possible to produce seed enough to plant all the sorghum cane which will be required by all the factories in the United States in 1892. These 12,000 heads have been divided into four classes.

Those coming from canes which give a juice of from 80 to 85 per cent purity, irrespective of sugar content, were placed in the first class; those having a purity of 75 to 80 in the second, and those from 70 to 75 in the third class, and the whole of the remainder in the fourth class.

The seed selections were taken from the following varieties: Early Amber, Undendebule (Nos. 1 and 2), Colman cane (cross of Orange and Amber), Folger's Early, Planters' Friend, Early Orange, Link's Hybrid, No. 160, No. 161, No. 110, No. 112, No. 208, No. 244, No. 289, and No. 350.

The method of making selections may not be devoid of general interest. The method pursued at Sterling was as follows:

Many thousands of canes of the particular kinds selected are run separately through hand mills and the juice from each one put in a tin can. These juices are then roughly tested by a hydrometer, giving reading, representing the percentage of total solids contained in them. If this reading is below a certain fixed standard the seed head from this cane is at once rejected, the standard of the juice being kept high enough to insure a rejection of the majority of the canes. If the first reading is satisfactory, the can and the seed head of the cane furnishing the juice therein receives a number. For instance, in the variety No. 112, 765 canes were found which came up to the required standard. These were again assorted by subjecting them to analysis and 185 samples were found to contain over 15 per cent of sugar. These seed heads were then saved and all the others from the variety rejected. From those which were saved another selection was made on the purity of the juice and 121 were found to have purities ranging from 75 to 80. These seed heads were preserved and all the others rejected. Thus of the many thousands of the canes of No. 112 submitted for examination only 121 seed heads were saved to distribute for planting next spring. With the force at the command of the station it was possible to test 3,000 canes per day. Of course it is not expected that canes showing a high percentage of sugar, say 18 per cent in the juice, will give seed which will on planting give a cane uniformly possessing this high quality. Were this true it would be possible to permanently secure and perpetuate each accidental variation showing a high percentage. Nevertheless, it is true that seed selected in this way has a tendency to produce a larger number of high-testing canes than before, and thus by continued selection it is possible to develop finally a permanent type showing a decided increase in sugar-producing power.

It must also be taken into consideration that in cases of seed selection the development of the particular varieties of cane should be largely influenced by the environment, that is, by the soil and climate; hence it is illogical to suppose that seed which has been selected in this way and permanently established at Sterling will do equally as well in a soil and climate radically different. It is the object of the Department in this work not to select and establish varieties which will do equally well in all parts of the United States, but to illustrate the methods of establishing varieties in one particular locality, so that the particular variety of cane which is suitable to any one locality may be speedily and scientifically established by selection in other places. In many cases the seeds which have been sent from Sterling, and which continue to give there the best results, have produced canes of much inferior quality in Louisiana and Mississippi, as will be seen by data given from those localities in another

place. After three years of study of all the heads of sorghum which could be obtained, amounting in all to nearly one thousand, it does not seem premature to give a list of those varieties which may be called the best. It must be understood, however, that this list is for a soil and climate similar to those in Western and Central Kansas, and this list can not be regarded as being absolutely correct for other and widely different localities.

From the results already obtained Early Amber will be suitable for earliest planting and manufacture or for very late planting when such is unavoidable. Earlier maturing varieties than Amber have been studied but none of them can as yet be recommended. Folger's Early has improved by selection, and No. 160 and No. 161 ripen soon after Amber and are much superior to it in many respects. Undendebule, Colman, and the well-known Link's Hybrid complete the list. To these may also be added Orange cane and its different varieties, which have proved so successful for manufacture but which did not deport themselves as well under selection as the heads mentioned. With the exception of Early Amber, all of these can be recommended in respect to high sugar content,good purity, and persistency of type. Folger's Early has a relatively high glucose content, but the purity is about the same as that of the others. Link's Hybrid is somewhat later in maturing and has a tall slender stalk which is liable to be blown down. This latter defect it shares with Nos. 160 and 161.

It is hoped that in the course of a year or two No. 161 can be hastened enough in maturing to take the place of Amber. The belief is entertained that these varieties, excepting Amber, are not superior to those commonly grown for sugar making, but selection on the lines already explained will probably result in considerable further improvement.

Hitherto the work of selection has been carried on mainly in the direction of high sugar and low glucose percentages, and in this respect its success has been most gratifying. In the future it seems evident that more particular attention must be paid to the purity of the juice, unless indeed Congress should see fit to permit the introduction of the process, for making sorghum sugar, by removing the gummy matters, which is proposed in another part of this report. Unless this can be done the greatest hope of the success of the sorghum-sugar industry lies in the direction of securing a juice of high purity and especially one low in the organic matters not sugar. It would be better, therefore, in this respect, to base at least one line of selection in this direction so as to eliminate as far as possible the gummy matters in the cane. The average purity of the juices of the sorghum which have been manufactured so far is not much, if any, above 65, while with sugar cane it is about 80 and with the sugar beet even higher. Of the varieties already selected and established the Colman and No. 161 give the best results in regard to purity, the number expressing the purity varying between 75 and 80. The importance of having a pure juice will be at once realized when it is known that the amount of sugar which is secured from a given weight of cane does not depend solely upon the contents of sugar in the juice but upon the amount of this sugar which the gummy and other uncrystallizable bodies in the juice will allow to crystallize. This was well illustrated in the work of the Department at Fort Scott, Kansas, in 1886. From sorghum cane the juice of which averaged 7.7 per cent and less than 60 purity only 21.5 pounds of commercial sugar per ton

of clean cane were made, while from sugar cane sent from Louisiana containing 10.45 per cent of sugar and having a purity of 73, and worked by precisely the same processes and under the same control, 144 pounds of sugar were made per ton.

It appears true of sorghum juices that the non-sugars, consisting of the glucose and solids not sugar taken together, may be in all about 4 to 5½ per cent of the juice. It has been shown by the three years' selection at Sterling that the glucose percentage can be reduced to a point at which it may be practically neglected, viz., to about one half of 1 per cent. The selection for the purpose of reducing the organic bodies not sugar has not been carried far enough to determine whether or not similar success can be expected. At the present, however, it appears that there is a kind of reciprocity existing between the glucose and solids not sugar so that as one is increased the other is diminished the sum thus remaining about a constant quantity. As a rule the varieties which have a low glucose content have a high content of organic solids not sugar, and the reverse is true. If this should be the correct view it would make the problem of selection a more difficult one and the wiser plan would be to pursue it in the direction of reducing the organic solids not sugar and increasing the glucose, provided the manufacture of sugar is to be carried on as it now is; while if the alcohol process for the separation of the organic solids in sugar should come into use then the wiser plan would be to pursue the selection with reference to diminishing the glucose to the least possible degree. The separation of the organic bodies not sugar, by alcohol, would leave a juice of remarkable purity and capable of yielding the maximum percentage of crystallizable sugar. It is highly probable, however, that all the non-sugars may finally be much reduced in amount by continued selection.

The results of the station work show that Early Amber, Folger's Early, and the various varieties of Orange have comparatively high glucose, and, as a rule, low percentages of solids not sugar. This accounts for the fact that in practice the Orange, although having a high percentage of glucose, has given uniformly good results. On the other hand, Undendebule, Colman cane, No. 161, Sorghum Bicolor, and Link's Hybrid show generally low percentages of glucose and high percentages of organic solids not sugar.

In general, therefore, it may be said that the lines of selection as indicated above will depend upon the method of manufacture to be pursued. If the method remains as it is, then without any question the direction of the lines of selection should be toward securing a juice of greater purity even should the sucrose content itself suffer. It is far better for the manufacturer to have a sorghum juice containing 12 to 13 per cent of sugar in the juice and a purity of 85 than to have one from 16 to 18 per cent sugar in the juice with a purity of 65.

I have already said that the cause of a poor yield of sugar in sorghum of high polarization is due to the presence of some form of carbohydrate or other organic body exercising a higher melassigenic power than invert sugar or any form of levulose or dextrose, and the results of the research carried on in the laboratory during the past eighteen months have disclosed to us the exact nature of this body and also revealed the method of separating it as indicated in another portion of this report.

Mr. John Dymond and Dr. W. C. Stubbs estimate that a fair average of Louisiana sugar cane, in the juice, would be as follows:

Solids	per cent..	15.00
Sucrose	do....	12.00
Glucose	do....	1.50
Purity		80.00

It would be of interest to compare these numbers with the averages of the sorghum worked in the four sugar houses at Attica, Medicine Lodge, Conway Springs, and Meade during the season of 1889, and also to compare it with the general average of the Colman cane during the present season:

	Louisiana sugar cane.	Factory sorghum.	Colman cane.
Total solids ....per cent..	15.00	17.46	19.48
Sucrose ....do....	12.00	11.08	14.88
Glucose ....do....	1.50	2.37	.84
Solids not sugar ....do....	1.50	4.01	3.76
Purity ....do....	80.00	63.45	76.37

It is easy to see from the above figures that the Louisiana cane yields a much larger percentage of sugar than sorghum. At the same time a glance will show that the removal of 3.76 per cent of the solids not sugar in the Colman cane would at once place it in the first rank of sugar-producing plants as compared with the others given above.

In the selections made at Sterling particular attention has always been given to the constitution of the sugar content. A variety which retains such a long time a high percentage of sugar in the field is of course preferable to one which rapidly loses its sugar content after having become fully ripe. The former allows more latitude for harvesting the crop, and also permits those canes which from various causes mature later than others, time to attain their maximum content before they are harvested, so that when they are finally worked they are in good condition. There are considerable differences in this respect among the different varieties. Some, as for instance the White African, and even the Early Amber, begin to retrograde soon after maturity; others are much more constant. Of all the varieties tried No. 161 has proved the most durable. One plot of this variety has held up its sugar content for seventy days, the longest period ever known, and, in spite of exceptionally adverse climatic conditions. Colman cane, which ripens somewhat later, is second in this respect. It seems probable that both these varieties will continue to disclose this good quality and will keep their sugar until second growth is far advanced. With this latter point is closely connected another, viz., the preservation of sugar content in the canes after they have been harvested. It is probable that the two are correlated and that the kind which keeps better in the field than others will also hold up its sugar content better after harvesting. It is very difficult for factories, to so arrange cutting, hauling, and manufacture to insure the selection of all the canes suitable after harvesting. The losses, therefore, in this respect are very great at every factory and the glucose ratio differs widely between field and diffusion battery.

If varieties of cane could be produced which might be cut and left for a week or so before working without serious damage it would be

a great step forward in the sorghum sugar industry. Work in selection on this line was planned, but owing to the press of other work and early frost it was abandoned during the present season.

In general, it appears that all the varieties of sorghum which have been tested may be divided into several classes. First, those varieties which have only a fair percentage of sugar and low glucose, as for instance Sorghum Bicolor, which for three years has had an average in its working period of 12.50 per cent of sugar and less than 1 per cent of glucose. Second. Varieties which have a less percentage of sugar and comparatively high glucose with a low percentage of solids not sugar. This variety is illustrated by the Early Orange, which for three years has shown during its working period about 14 per cent of sugar and 2 per cent of glucose. Third. Varieties which have high sugar content and low glucose. This variety is illustrated by Undendebule No. 1, which has shown for three years during its working period 15.50 per cent of sucrose and 0.70 of glucose. No. 161 has also shown good results in this direction, having for two years an average of 15 per cent sugar and about 0.50 per cent glucose. Fourth. Varieties with a moderate percentage of both glucose and sucrose. This class is illustrated by No. 250, an African variety which has given for two years an average of 12.50 per cent sucrose and 1.25 per cent glucose.

In respect of the detailed studies of the different varieties grown at Sterling, reference will be made to the bulletin of the Department, No. 29, which will contain all the data collected from the Sterling station during the present year.

EXPERIMENTS WITH SORGHUM NEAR COLLEGE PARK. MARYLAND.

The experiments made in 1889 near College Park were rendered entirely nugatory by the exceptionally wet season, which prevented planting the cane at the proper time, interfered with its cultivation, and retarded its maturity. Hoping to obtain better results it was decided to continue the work, on a small scale, during the present season. Four acres of land were leased from Mr. D. M. Nesbit, and this land was divided into eight equal portions. The land was in the form of a parallelogram, the length lying east and west and was twice as long as it was wide. An attempt was made to secure land of a perfectly uniform nature, but even in so small a portion as 4 acres this was found to be impossible. The western part of the land was a gravelly loam, while about 1½ acres of its eastern portion was much more sandy and less fertile than the western part.

The eight subdivisions were planted north and south and were numbered by the letters of the alphabet beginning on the west side with plot A and continuing to the east end to plot H, each plot containing half an acre. In an eastern and western direction the plots were divided into five equal portions and the numerals from 1 to 40 were applied to the small plots made by the crossing of the eight north and south divisions with the five east and west divisions, each plot containing one-tenth of an acre.

The method of plotting the field and the number of each plot are shown in the diagram.

On plots 1, 6, 11, 16, 21, 26, 31, 36, 3, 8, 13, 18, 23, 28, 33, 38, Link's Hybrid was planted; on plots 2, 7, 12, 17, 22, Early Amber; on plots

4, 9, 14, 19, 24, 29, 34, and 39, Undendebule; on plots 27, 32, 37, Red Liberian; on plots 5, 10, 15, and 20, Early Orange; on plots 25, 30, 35, and 40, Improved Orange and two rows of Early Orange to finish out the plot of which there was not enough Improved Orange seed to complete.

The principal object of the experiment was to determine the influence of different kinds of artificial fertilizers on the composition of the cane. The fertilizers employed and the method of distributing are indicated in the following scheme:

N

	1	6	11	16	
	2	7	12	17	
W	3	8	13	18	E
	4	9	14	19	
	5	10	15	20	

S

A B C D

Link's Hybrid:
Plots 1, 6, 11, 16, 21, 26, 31, 36.
3, 8, 13, 18, 23, 28, 33, 38.

Early Amber:
Plots 2, 7, 12, 17, 22.

Undendebule:
Plots 4, 9, 14, 19, 24, 29, 34, 39.

N

	21	26	31	36	
	22	27	32	37	
W	23	28	33	38	E
	24	29	34	39	
	25	30	35	40	

S

E F G H

Red Liberian:
Plots 27, 32, 37.

Early Orange:
Plots 5, 10, 15, 20.

Improved Orange:
Plots 25, 30, 35, 40.

Scheme for distributing fertilizers.

1............Cottonseed meal.
2............Superphosphate.
3............Kainite.
4............Nitrate of soda.
5............(1, 2, and 3) equal portions of each.
6............(2, 3, and 4) equal portions of each.

On A........No. 5.
On B........No. 2.
On C........Nothing.
On D........No. 3.
On E........No. 4.
On F........Nothing.
On G........No. 6.
On H........No. 1.

Basis of application.

[Pounds per acre.]

No. 1....... 600.
No. 2....... 600.
No. 3....... 600.
No. 4....... 400.
No. 5....... 600.
No. 6....... 600.

In regard to taking samples for analysis the following plan was pursued:

Beginning, for instance, with the Early Amber, which was the first to ripen, samples of the cane were taken by cutting about one hundred canes of Early Amber from each of the different lettered plots on which it was planted, viz A, B, C, D, and E. These canes were thrown together, well mixed, and divided into four parts, and one part sent to the laboratory for analysis. In this way samples were taken from each of the plots under the influence of each kind of fertilizer on the same day. On September 11 five samples of Early Amber were sent to the laboratory for analysis, including one sample from each of the lettered plots on which the Amber was grown. On the 19th, 24th, and 30th of September, and the 3d and 10th of October, samples were taken in the same way from each of the plots of Amber. The other varieties were treated in the same way when they approached maturity, the object being to secure a study of the characteristics of the cane at about that period at which it would be used for manufacturing purposes if grown on a large scale.

The character of the cane was rather disappointing, with the exception of the Early Amber, indicating a crop which would have been unprofitable for manufacturing purposes.

With the exception of the Early Amber the growth of cane was luxuriant on all the plots except those at the extreme eastern end in the poor ground. The Early Amber, as is usual with this variety, was very small as compared with the other varieties, and yet the yield per acre was fair. The mean analyses of the Early Amber variety for the different plots are as follows:

	A	B	C	D	E
Total solids .... per cent.	17.5	17.7	17.1	16.7	16.0
Sucrose ....do....	13.4	13.1	12.9	12.1	11.4
Glucose ....do....	1.3	1.7	1.8	2.2	2.5
Purity	76.5	73.9	75.0	72.5	71.0

The analyses of the Early Orange were commenced on the 20th of September; subsequent sets of samples were examined on the 1st, 4th, 13th, 18th, and 30th of October. The mean results were as follows:

	A	B	C	D	E	F	G	H
Total solids . per cent..	14.5	15.3	15.0	14.5	15.5	15.3	15.2	16.1
Sucrose ....do....	7.7	8.9	8.4	8.1	9.9	9.7	9.7	10.6
Glucose ....do....	4.8	4.6	4.5	4.8	4.1	4.2	4.1	4.0
Purity	53.1	57.3	56.1	55.0	64.1	63.0	63.7	64.5

The analyses of Link's Hybrid were commenced on the 22d of September and continued on the 25th and 29th of September and the 6th, 11th, and 29th of October. The mean results obtained were as follows:

	A	B	C	D	E	F	G	H
Total solids.per cent..	14.6	14.9	14.4	14.3	15.8	15.1	14.7	15.9
Sucrose ....do....	10.2	9.5	8.9	9.8	11.8	10.1	10.7	11.3
Glucose ....do....	2.2	3.1	3.9	2.7	1.8	2.8	2.3	2.2
Purity	69.9	64.5	61.4	68.3	74.8	66.5	72.8	71.5

The analyses of Undendebule were commenced on the 26th of September and continued on the 2d, 17th, and 25th of October. The mean results obtained follow:

	A	B	C	D	E	F	G	H
Total solids.per cent..	13.5	14.2	14.6	15.0	15.9	15.6	16.3	16.1
Sucrose ....do....	9.3	8.9	9.1	11.3	11.2	10.2	11.4	10.9
Glucose ....do....	2,4	3.3	3.3	2.1	2.2	2.8	2.6	2.4
Purity	68,4	62.3	62.4	75.3	74.0	65.1	69.6	67.6

The analyses of Improved Orange were commenced on the 16th of October and continued on the 21st and 27th. Following are the means obtained:

	E	F	G	H
Total solids ....per cent..	15.8	15.3	15.4	15.6
Sucrose ....do....	11.3	10.9	10.7	10.7
Glucose ....do....	3.8	4.2	4.0	4.0
Purity	71.1	71,3	70.0	68.5

Analyses of Red Liberian were commenced on the 15th of October and continued on the 20th and 28th. Following are the mean results obtained:

	F.	G.	H.
Total solids ....per cent..	14.4	14.5	15.2
Sucrose ....do....	3.9	4.5	5.2
Glucose..do....	6.6	6.5	6.2
Purity	26.8	30.4	33.9

In order to obtain a comparison in richness of sugar of the results on all the different plots with the different kinds of fertilizers, the following tabular arrangement has been constructed. Taking the mean results of each variety they have been arranged in the following order:

First, in the order of highest sucrose; the plot giving, for instance, the highest sucrose being placed first and those containing the next subsequent percentages in order below. For instance, in the case of Early Amber, it was found that the highest sucrose was in plot A and there is a regular decrease from plot A, so that this was arranged in alphabetical order, A, B, and so on. In the next group are con-

tained the plots with the lowest glucose beginning with the lowest and continuing to the highest. In the next group are collected the mean purities, beginning with the highest purity and continuing to the lowest purity in order.

Classification of plots in respect of sucrose, glucose, and purity.

Variety.	Highest sucrose.								Lowest glucose.								Highest purity.							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Early Amber	A	B	C	D	E	...	...	...	A	B	C	D	E	...	...	...	A	C	B	D	E	...	...	...
Early Orange	H	E	F	G	B	C	D	A	H	G	E	F	C	B	D	A	H	E	G	F	B	C	D	A
Link's Hybrid	E	H	G	A	F	D	B	C	E	A	H	G	D	F	B	C	E	G	H	A	D	F	B	C
Undendebule	G	D	E	H	F	A	C	B	D	E	A	H	G	F	B	C	D	E	G	A	H	F	C	B
Improved Orange	E	F	G	H	...	...	...	...	E	F	G	H	...	...	...	...	F	E	G	H	...	...	...	...
Red Liberian	H	G	F	...	...	...	...	...	H	G	F	...	...	...	...	...	H	G	F	...	...	...	...	...

An analysis of this table shows that the plots have the following relations:

Plots.	Rank.								Total.
	1	2	3	4	5	6	7	8	
A	3	1	1	3	0	1	0	3	12
B	0	2	1	0	2	1	4	2	12
C	0	1	2	0	1	2	2	4	12
D	2	1	0	3	2	1	3	0	12
E	5	4	2	0	1	0	0	0	12
F	1	2	4	2	2	4	0	0	15
G	1	5	6	2	1	0	0	0	15
H	6	1	2	4	1	0	0	0	14

Per cent.:

A for first place	25.0
B for first place	00.0
C for first place	00.0
D for first place	16.7
E for first place	42.7
F for first place	8.3
G for first place	8.3
H for first place	50.0

Multiplying each rank of each plot by the number of times it occurs and dividing by 8 will give the mean position of each plot in the series.

A = 6.25 E = 3.00
B = 8.37 F = 7.38
C = 8.63 G = 5.30
D = 6.63 H = 4.38

In reviewing these results the following facts are noticed: With Early Amber the highest sucrose was produced by fertilizer 5, followed in order by 2, 0, 3, and 4. The lowest glucose appears in same order.

The highest purity was found with No. 5, followed by 0, 2, 3, and 4.

With Early Orange the highest sucrose was produced with No. 4, followed in order by 2, 0, 3, and 5.

The lowest glucose was found with No. 4, followed by Nos. 0, 2, 3, and 5.

The highest purity was found with No. 4, followed in order by Nos. 2, 0, 3, and 5.

The above comparison, however, is not strictly just on account of the fact that all varieties were not planted on all the plots. It will be better, therefore, to compare only those plots and varieties which present a complete comparison. These plots are A, B, C, D, and E, and the varieties Early Amber, Early Orange, Link's Hybrid, and Undendebule.

Classification of Plots A, B, C, D, and E, with varieties Early Amber, Early Orange, Link's Hybrid, and Undendebule.

Variety.	Highest sucrose.					Lowest glucose.					Highest purity.				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Early Amber	A	B	C	D	E	A	B	C	D	E	A	C	B	D	E
Early Orange	E	B	C	D	A	E	C	B	D	A	E	B	C	D	A
Link's Hybrid	E	A	D	B	C	E	A	B	D	C	E	A	D	B	C
Undendebule	D	E	A	C	B	D	E	A	B	C	D	E	A	C	B

With Link's Hybrid the highest sucrose was found with No. 4, followed in order by Nos. 5, 3, 2, and 0.

The lowest glucose was found with No. 4, followed in order by Nos. 5, 2, 3, and 0.

The highest purity was found with No. 4, followed in order by Nos. 5, 3, 2, and 0.

With Undendebule the highest sucrose was found with No. 3, followed in order by Nos. 4, 5, 0, and 2.

The lowest glucose was found with No. 3, followed in order by Nos. 4, 5, 2, and 0.

The highest purity was found with No. 3, followed in order by Nos. 4, 5, 0, and 2.

A general comparison of the numbers is given in the following table:

Plot.	Rank.					Total.
	1	2	3	4	5	
A	3	3	3	0	3	12
B	0	4	3	3	2	12
C	0	2	4	2	4	12
D	3	0	2	7	0	12
E	6	3	0	0	3	12

Multiplying the times each plot occurs in the series by the number of the rank and dividing by 5 we obtain the mean position of each plot.

1 E=5.4	4 B=7.8
2 A=6.6	5 C=8.8
3 D=7.4	

Hence it appears that in general results nitrate of soda (fertilizer applied to plot E) has produced the most favorable effects. Followed by this is a mixture of equal parts of cottonseed meal, superphosphate, and kainite. Next in order comes kainite alone. In the next rank we find superphosphate alone, while the plot C, which received no fertilizer at all, showed the poorest results.

These data are more valuable in indicating the methods of studying the effects of intensive culture on sorghum than for the definite knowledge obtained. It is evident at once that only several years of continual investigation would make a solution of the problem possible.

The agricultural data are briefly given in the following resumé:

Plots A, B, C, and part of D were rather light soil, containing a large percentage of sand and having perfect natural drainage; the remainder of the plots was more clayey and compact. The light soil favored the growth of sorghum so that it matured on an average one month earlier than that in the other plots. It is worthy of note that the sorghum showed far greater sensitiveness to difference in soils than a field of maize grown next to it on the same kind of ground. The following statement gives the number of stalks per acre, and the gross weight per acre, including the blades and seed heads, and the net weight per acre including only the clean cane for each variety on the different plots. These weights were all taken on the same day, viz., the 15th of October, and the weight per acre is based upon a carefully measured portion of each plot the whole of which was harvested and weighed in the manner indicated:

Plots.	Link's Hybrid.			Early Amber.			Undendebule.		
	Stalks per acre.	Gross weight per acre.	Net weight per acre.	Stalks per acre.	Gross weight per acre.	Net weight per acre.	Stalks per acre.	Gross weight per acre.	Net weight per acre.
		Pounds.	*Pounds.*		*Pounds.*	*Pounds.*		*Pounds.*	*Pounds.*
A	22,000	23,500	17,500	20,000	15,000	12,000	23,000	32,000	27,500
B	27,000	29,500	21,500	21,000	10,000	7,500	18,000	27,500	21,500
C	15,000	23,000	17,000	18,000	7,500	6,000	27,000	29,000	21,000
D	21,000	36,000	26,500	18,000	12,500	9,000	23,000	20,000	14,000
E	24,000	37,000	27,000	18,000	6,000	4,500	21,000	22,500	16,500
F	25,000	32,500	24,500	....	....	....	21,000	24,000	16,500
G	21,000	25,500	19,000	....	....	....	17,000	21,500	15,000
H	23,000	28,500	19,500	....	....	....	20,000	22,000	15,000

Plots.	Early Orange.			Improved Orange.			Red Liberian.		
	Stalks per acre.	Gross weight per acre.	Net weight per acre.	Stalks per acre.	Gross weight per acre.	Net weight per acre.	Stalks per acre.	Gross weight per acre.	Net weight per acre.
		Pounds.	*Pounds.*		*Pounds.*	*Pounds.*		*Pounds.*	*Pounds.*
A	18,000	33,000	25,500	....	....	....	....	....	....
B	21,000	27,500	22,200	....	....	....	....	....	....
C	20,000	22,000	17,000	....	....	....	....	....	....
D	18,000	27,500	21,000	....	....	....	....	....	....
E	....	....	....	17,000	13,500	10,000	....	....	....
F	....	....	....	18,000	14,500	10,500	21,000	30,000	23,000
G	....	....	....	18,000	17,000	11,500	22,000	24,500	19,500
H	....	....	....	17,000	18,000	13,000	14,000	22,500	16,500

EXPERIMENTS AT THE MISSISSIPPI AGRICULTURAL EXPERIMENT STATION, STARKVILLE, MISSISSIPPI.

Quite a number of the seed heads selected at the Sterling station in 1889 were sent to the director of the Mississippi Agricultural Experiment Station, Prof. S. M. Tracy, with the request that he coöperate with the Department in testing the value of the different varieties sent in the soil and climate of Mississippi. The cultiva-

tion of the samples was undertaken solely at the expense of the Mississippi station, and in the analyses the Department of Agriculture furnished only the hand mill which was used in expressing the juice from the canes. The analyses were made by Mr. L. G. Patterson, the chemist of the experiment station. A review of the analytical data obtained strongly illustrates the statement which has already been made that the production of a superior variety of cane by selection in one locality will not always insure the development of similar canes from seeds which are planted at a great distance from the original station, where the conditions of soil and climate are quite unlike those under which the standard variety of cane has been developed.

In a variety of Red Liberian No. 137, coming from a cane whose juice showed a content of total solids equal to 19 per cent, analyses were made at the Starkville station beginning September 1 and running to September 10, in which the content of sucrose in the juice of the cane varied from nothing to 4.9 per cent, while the glucose varied from 5 to 7.45 per cent. The mean numbers were sucrose 3.0 per cent; glucose 6.07 per cent. It seems hardly possible that a selected seed head could deteriorate so rapidly in being removed to a different locality. Analyses were continued with this variety planted from a seed head from plot No. 138 of the 1889 Sterling number, showing 18° Brix; No. 125 with a sucrose content of 15.04 per cent; No. 135, showing 18° Brix and No. 125 bis with 14.81 per cent of sucrose. These experiments were continued from September 1 to October 2, but in no case was the result comparable with the character of the parent cane. The percentage of glucose was almost uniformly higher than that of sucrose, and the result of the experiments with this series of selected seed heads was a record of most remarkable deteriorations. In several cases the polariscope failed to reveal any sucrose whatever present in the juices of the cane.

The mean percentages obtained in the juice were as follows:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
138........	12.2	4.8	4.6
125........	12.2	4.2	4.7
135........	11.8	4.3	4.8
125 bis....	14.1	6.0	4.8

Experiments were also made with selected seed heads from the Undendebule variety of cane selected at Sterling last year and of the following descriptions; Plot No. 297 of 18° Brix; No. 31 of 21° Brix; No. 31 of 20° Brix; No. 254 of 15.53 per cent sucrose. These analyses were commenced on the 2d of October and continued until the 4th of October. In many cases good results were obtained, but in no case was the parent cane excelled. With stalks produced from seed head plot No. 254, analyzed on the 3d of October, the sample was found to contain 15.2 per cent of sucrose and 0.54 per cent of glucose, and showing 20° Brix. Many of the other analyses showed fairly good percentages, but the mean of all of them would indicate a general deterioration in the most marked degree from the parent canes. Seed head from plot 31, 21° Brix, is a partial exception.

The mean results follow:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
297........	12.0	6.4	1.7
31.........	18.3	13.1	1.4
31 bis	12.1	6.7	2.0
254.......	15.6	10.5	1.3

Analyses of the variety Rio Blanco were made on October 4. The samples were taken from canes grown from seed-head from plot 107, of 21° Brix, and from seed head plot 107, of 20° Brix. The results here also showed the most remarkable deterioration. In no case did the Brix of the samples grown equal that of the parent cane.

The means were as follows:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
107........	13.3	7.8	3.8
107 bis	15.2	9.2	3.5

Experiments were also made with the India and Orange varieties from Sterling, plot 289 of 1889, showing 21° Brix, and from selected seed head 14,175 of India and Orange, showing a sucrose content of 16.42 per cent, the experiments having been made on the 4th and 6th of October. In these cases, also, there was a marked deterioration. In the case of the canes developed from seed head No. 14,175, the highest percentage of sucrose reached was 13, with a glucose content of 1.73 per cent and 18° Brix. This was on the 6th of October. The lowest sucrose content was 4.2 per cent. The average is far below the percentage of sucrose in the original cane, which as before stated was 16.42. Means:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
289........	14.7	9.6	2.9
14,175.....	15.9	10.1	2.8

Experiments made with a variety of Honduras, grown from seed head 12,677, with a sucrose content of 16.72 per cent, showed the same reversion, only in a much more marked degree.

Experiments with Sorghum Bicolor, seed head No. 13,799, with a sucrose content of 13.25 per cent, also failed to develop as rich a cane as the parent, the highest percentage of sucrose found being 12.2, with a percentage of glucose of 0.83.

Mean results.

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
13,799.....	14.3	8.4	1.1

Experiments were made on the 11th of October with Link's Hybrid variety, from plot 194, seed head 11,586, with a sucrose content of 16.01 per cent. The results also were very poor, the highest sucrose content obtained being 10.3 per cent.

Mean results.

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
194	14.7	7.6	4.3

Red Liberian, examined on the 11th of October, from seed-head No. 13,631, showing a sucrose content of 13.52 per cent, gave somewhat better results than the same variety examined earlier in the season, the highest sucrose found being 11 per cent. From the same variety, seed head 13,655, showing 13.97 per cent sucrose, the results were poorer, the highest sucrose content found being 9.1 per cent.

The means were:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
13,631.....	14.4	8.5	1.9
13,655.....	13.7	6.2	4.5

From a cross of Amber and Orange, seed head 13,927 having a sugar content of 16.85 per cent, much better results were obtained. The examination was made on the 17th of October. The percentages of sucrose obtained in the samples examined on that day were as follows: 15.1, 13.6, 14.2, 11.9, 13.5, 13.5, 11.9, 14.1, 13.7, and 12.9.

The percentages of glucose in all except three instances fell below 1, while the purities were very high. This sample appears to have given the best and most uniform results of any examined during the season.

The mean data are:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
13,927.....	17.6	12.5	0.75

On the 18th of October analyses were made of Link's Hybrid again from seed head 11,491, showing a sucrose content of 16.69 per cent, the results being also favorable. The percentages of sucrose were 13.8, 15, 12.6, 13.4, and 14.3, the glucose averaging about 1 per cent, and the purity being high. Analyses of the same plot, continued on the 20th of October, showed results equally good. The means for the two days are:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
11,491.....	18.4	13.6	1.2

Samples of Link's Hybrid, from seed head 13,897 with a sucrose content of 15.66 per cent, analyzed on the 20th of October, gave less

favorable results, the highest sucrose content found being 14.5 per cent, and the lowest 8.8 per cent. Samples from another plot, grown from seed head 11,558, showing a sucrose content of 16.21 per cent, gave still less favorable results, and the same is true of another plot grown from seed heads Nos. 13,379 and 11,585. The means are:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
13,897.....	[illegible]	11.6	1.5
11,558.....	[illegible]	9.6	1.8
13,379.....	15.1	9.5	2.4

Red Liberian examined later in the season, namely, on October 29, still showed the same extremely poor characteristics as were manifested in the earlier part of the season, with the exception of canes grown from seed head from plot 127, showing 19°.5 Brix. The means from this plot were:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
127........	19.5	14.6	1.2

The analyses were completed on the 31st of October by the examination of a sample of a cross of Amber and Orange from seed head No. 12,142 with a sucrose content of 17.99 per cent. In the three samples examined the sucrose was 15.0, 12.5, and 13.8 per cent, and the glucose 1.01, 2.17, and 1.72 per cent, and the Brix 19°.5, 18°.0, and 18°.0. Means:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
12,142.....	18.5	13.8	2.0

The full discussion of the details of these analyses will be reserved for Bulletin No. 29. In general, however, it may be said that the Red Liberian, which has done fairly well in Kansas, was a total failure in Mississippi with the exception of one plot. The same is true but in a less degree of the Undendebule, although some analyses of this last variety were quite favorable, but the average of them all will show a much lower percentage of sucrose than in Kansas. Rio Blanco, which is a kind of Orange cane, also did very poorly in Mississippi, and the same is true of the cross of India and Orange. The Honduras in Mississippi as elsewhere has shown itself to be a worthless cane for sugar purposes. Sorghum Bicolor also did poorly in Mississippi. The best results obtained were from the cross of Amber and Orange, the one plot of Red Liberian, and Undendebule from plot 254, seed head 13,336, of which the mean analyses showed:

Plot No.	Total solids.	Sucrose.	Glucose.
	Per cent.	*Per cent.*	*Per cent.*
254........	18.7	14.8	0.57

This brief review of the data obtained at the Mississippi station tends to show that if sorghum sugar culture is to become a success in that locality it will be quite necessary that a line of experiments in seed selection should be carried on similar to those which have produced such excellent results in Kansas. There is every reason to believe that by the pursuit of the same policy all the standard varieties of cane might be developed which would be as suitable to the soil and climate of Mississippi as those which have been developed in Kansas are to the meteorological conditions of that locality. Still, it must not be forgotten that the general tendency of the researches of the Department has been to show that sorghum does better in a semi-arid locality, and that therefore we ought not to expect as high a development in sugar-producing qualities in Mississippi as can be obtained in more arid regions.

EXPERIMENTS WITH SUGAR BEETS.

From Mr. Henry T. Oxnard, the Department purchased 3 tons of sugar beet seed, of which the greater portion was the variety known as the Kleinwanzlebner, grown by Dippe Brothers, of Quedlinburg. In addition to this, however, smaller quantities of the White Improved Vilmorin were purchased, together with the varieties of beets grown by Lemaire and Florimond and Bulteau Desprez. These different varieties were put in 1 pound packages and sent to over one thousand different persons, mostly to those who had made special inquiry for them. Accompanying these packages were directions for preparing the soil and planting and cultivating the beets. Later directions were sent for harvesting and sampling the beets and for sending samples to the Department for analysis. Nearly one thousand different samples of beets were received by the Department, of which the analyses were made and the results communicated to the farmers sending them. In addition to this work a large number of the beet plots was personally inspected by agents of the Department, and particular inquiry was directed to a large number of farmers in regard to the methods of cultivation which they had pursued. Only in a few instances were the directions of the Department followed out to the letter. In most cases the planting and cultivation of the beet seed were conducted according to such methods as the agriculturist might hit upon at the time.

From the information gathered, it was found that the chief variation from the instructions was in the preparation of the soil. In very few cases was a subsoil plow used and most of the beets which were sent to the Department were evidently grown in soil of insufficient depth. In some cases where the exact directions for cultivation were carried out the character of the beets received showed by contrast with the others the absolute necessity of employing the best methods of agriculture for their production. It was not thought best the first year to make any effort to obtain from the farmers the exact yield of their beets per acre. The difficulty of securing such information is almost insurmountable. In the first place the amount of land under cultivation is usually guessed at and in very few cases are exact measurements made. The results, therefore, at best are only estimates unless the absolute control of measurements and weights can be secured. It was thought best, therefore, to depend for estimates of yield upon the actual quality of the beets produced, since it

is well known that about 40,000 beets of fair quality can be produced upon an acre. It is therefore fair to presume that the yield per acre would be, within ordinary limits, the weight of the average beet sent for analysis multiplied by 40,000. When, however, it is necessary to speak of beets weighing from 2 pounds upward the rule no longer holds good, as it would be evidently impracticable to grow 40,000 beets of such a size upon an acre. It is fair, however, to estimate the yield upon beets weighing about 1 pound at 40,000 per acre or 20 tons. It is not meant by this that a yield of 20 tons can be obtained by farmers at the beginning, for this is not the case; it is only exceptionally that such a yield can be secured. When, however, the exact methods of beet culture are thoroughly understood and the method of fertilizing and preparing the soil studied, it will not be difficult, with favorable climatic conditions, to secure a yield of beets equal to 20 tons per acre.

For the information of those who might desire hereafter to enter upon the cultivation of the beet, the following brief summary of the methods of preparation of the soil, fertilization and cultivation is given:

The soil which is to be planted in beets, if fertilized with stall manure, should have a dressing of well rotted manure applied in the autumn and plowed under. The plow should be placed at a depth of 8 or 9 inches and should be followed with a subsoiler, which should loosen the ground to the depth of 6 or 7 inches more, without throwing the subsoil on top. The layer of stall manure would thus be placed at a point about half way from the surface to the total depth to which the soil is loosened. If the stall manure be well rotted when applied the soil will be in excellent condition by spring for the reception of the beets. The farmer can not be too strongly cautioned against the application of the stall manure in the spring, nor against its application in the autumn unless in the well rotted condition mentioned above. There are many soils, in fact, in which the application of the stall manure is not at all necessary, namely, those soils which are rich in organic matter and those which have not been exhausted by long years of cultivation.

In regard to artificial fertilizers, the standards for the sugar beet, of course, are those containing phosphoric acid, potash, and nitrogen. The amount of nitrogen applied in artificial fertilizers, however, should be the minimum necessary for the production of a good vegetation. Any additional amount of nitrogen in excess of this quantity tends to produce a larger beet at the expense of its sugar content, and is to this extent injurious.

Phosphoric acid is usually employed in the form of superphosphates which are easily soluble by the growing crop.

Potash salts of organic origin have proved themselves to be the best; those which come from the beet-sugar factory itself being, of course, best suited for the nourishment of the succeeding crop. The potash and phosphoric acid in wood ashes also act with excellent effect. Inorganic potash salts produce a good effect when the soil is deficient therein. Of these inorganic salts kainite and high-grade sulphate are generally employed.

The artificial fertilizers may be applied in the spring if they are thoroughly plowed under by stirring the surface of the soil with an appropriate cultivator. The potash salts, however, should rather be applied in the autumn, inasmuch as it is important that they should be buried as deeply as possible in the soil.

For a full discussion of the principles of fertilization reference must be made to Bulletin No. 27 of the Chemical Division.

Planting.—The beet seed should be planted in rows about 18 inches apart. In very fertile soils the rows are sometimes placed only 16 inches apart. These rows should be made as straight as possible, and the beets are best planted in a small way by a hand drill and on a large scale by a horse drill. When a horse drill is used two or more rows can be planted at once. The rows when the contour of the soil permits are better made north and south than east and west, although this is a matter of no very great importance. It is highly important, however, that they should be perfectly straight, so that the beets will not be injured during cultivation. In some localities it is customary to keep the beet seeds in a moist and warm condition for about forty-eight hours before planting them; they are thus quite ready to germinate when placed in the soil. This is a perfectly safe process if, at the time the beets are planted, the soil is moist and warm enough to continue the germinating process, but if, on the other hand, the soil should be too cold or too dry, then this previous maceration of the seed might prove injurious to its vitality.

The surface of the soil in which the beets are planted should be, immediately previous to the planting, thoroughly stirred and loosened to the depth of 2 or 3 inches, and all clods should be broken and the surface left comparatively smooth. Much of the cultivation of the beets may be secured before their planting by having the soil in perfect tilth. The thorough plowing and harrowing of the surface just before planting destroys all the weeds which may have germinated, and thus leaves the beets a fair chance with the weeds in the race for life.

It is highly important that the beet seed should be planted very thick, much thicker, in fact, than would be required if they should all germinate. The policy, however, of planting the beet seed just where the beets are expected to grow, and in no greater quantities, would prove most disastrous, since at the best many of the seeds do not germinate, and thus there would be left long distances where no beets would grow. The very best growers of beets use about 15 pounds of seed per acre, although if the seeds were all good probably 3 or 4 pounds might be amply sufficient to obtain a good stand. The advice, therefore, is given to farmers to plant about 10 to 15 pounds per acre, since a little additional expense for seed will be more than compensated for in the uniform stand obtained. The beets should be covered to a uniform depth of about 1 inch. If they are planted much deeper than this it may be difficult for the tender plantlet to reach the surface; if at a less depth dry weather supervening may prevent their germination.

When the beets are fully above ground the spaces between the rows may be thoroughly stirred by the horse hoe, furnished with shields, described in Bulletin No. 27. These shields prevent the young plant from being covered, while the hoe thoroughly stirs the soil between the rows and kills all sprouting weeds. As soon as the beets begin to show three or four leaves the process of thinning should take place. This may be done altogether by the hand and hoe, or partly by a horse hoe. A very common method, when the stand is very thick, is to cross the rows with a slender horse hoe, which will take out about 6 inches of each row and leave about 4 inches untouched. The most healthy beet remaining in the 4-inch piece is left, while all the others are carefully taken out by the hand or hand

hoe. This will leave one beet for every 10 inches, which is quite thin enough. In fact, an effort should be made to have a beet every 9 inches in the row in rich soils, while in very poor soils the distance may be left at 10 to 12 inches. In very rich soils it may be brought down as low as 8 inches. This thinning process is the most laborious and expensive of all the processes in beet culture, but is absolutely necessary to secure a good crop.

The surface cultivation can be carried on almost exclusively by horse power, and the ground should be thoroughly stirred between the rows and to a considerable depth at least once a week until the foliage of the beet begins to cover pretty thoroughly the spaces between the rows. If the cultivation of the beet begins about the 20th of May it should continue at least until the 1st of July, and in some instances for a longer time. The more attention which is paid to cultivation the larger will be the yield, other things being equal.

It is highly important that beet growers should realize the immense amount of labor which is necessary to produce a good beet crop. Farmers who are accustomed to growing maize and wheat are apt to think that beets can be grown over large areas much the same way, while, in point of fact, it requires as much labor to grow 10 acres of beets as it would 100 acres of maize. Mistakes are thus often made by beginners in attempting to grow more beets than they can attend to, with resulting failure. All farmers not accustomed to grow beets should begin with small quantities, and when the art has once been learned they will be able to estimate the area which they can successfully cultivate.

STATUS OF THE MANUFACTURING INDUSTRY OF BEET SUGAR IN THE UNITED STATES.

The readers of the agricultural reports are well aware, from what has already been published, of the fact that a beet-sugar factory has been in operation in Alvarado, California, for more than ten years. This factory has proved quite successful and the culture and manufacture of the sugar beet is now an established industry in that locality. For three years another large factory has been in operation at Watsonville, California, and from reports, which are accessible to the Department, this has also proved to be successful. Last year a large sugar factory was built at Grand Island, and as far as manufacturing operations are concerned was completely successful. This factory contains the latest and best forms of machinery suitable to the production of beet sugar and was built and operated upon the most approved plans of sugar technical engineering.

The beets which were brought in for manufacture were uniformly of a high character, as will be seen from a discussion of the analytical data relating thereto further on. The data of manufacture, however, are not accessible to the Department, the factory being purely a private corporation and not feeling disposed to furnish the Department with an itemized account of expenditures and receipts. From the best information accessible to us, however, it appears that about 5,000 tons of beets were received for manufacture and that the amount of sugar made per ton of these beets was probably 240 pounds. If the company should apply for the bounty given by the State of Nebraska, which is 1 cent a pound, it would be possible to give the exact amount from the report of the bounty paid. The Department,

however, is not in possession of any facts in regard to this matter and hence only an estimate of the yield can be given.

By the courtesy of the managers of the company the Department was permitted to station a chemist at Grand Island, who had charge of the sampling of the beets as they came to the factory in wagons or carloads. Nearly three thousand analyses of samples were made and the full tabulated reports of these analyses will be found in a bulletin (No. 29) which will soon be issued on this subject, and a brief discussion of them will be found elsewhere in this report.

The proprietors of the factory were so encouraged by the season's work that they have decided to erect another large factory at Norfolk, Nebraska, and work on this factory is now going on.

Manufacturing experiments, on a small scale, with sugar beets, were also carried on during the season just past at Medicine Lodge, Kansas. About 80 acres of beets in all were harvested for the factory, and a summary of the work done will be given in another place and the details published in the bulletin above mentioned.

In general, the following remarks may be made concerning the last season's work in the beet-sugar industry, from a commercial point of view, in Nebraska and Kansas.

The summer in both localities was exceptionally dry. For this reason and on account of lack of knowledge among the farmers in regard to the proper methods of raising beets the average crop was very short. In Nebraska the exact tonnage can not be known, but probably it would not average more than 2 or 3 tons of beets per acre; in Kansas the average seems to have been somewhat higher. In many cases farmers obtained 10 and even 15 tons of beets per acre, showing that even in adverse conditions of season a reasonably large crop may be harvested when all other conditions necessary to the proper growth of the crop are attended to.

As might well be expected from the small yield, the farmers in general were dissatisfied with the season's work. It is not reasonable to expect satisfaction from a crop of so low an average when the labor of growing it is so great; but while the farmers are dissatisfied it must be confessed that a great deal of this dissatisfaction must be attributed to their own lack of knowledge of the subject or to their disinclination to put upon the beet fields the proper amount of labor and culture at the proper time. Instead of being therefore deterred from continuing the production of sugar beets, it would seem wiser on the part of the farmers to study carefully the methods of agriculture pursued by those who made a success of beet culture, and to imitate those methods during the coming season. The fact should not be forgotten, however, that even with the poor results obtained the beet crop was uniformly better than the average of other crops in the same locality.

It would be useless to hold out to the farmer the hope of financial reward from a beet crop which would average only 3 tons per acre; but if from this acre he could produce 10 to 15 tons of beets then his venture would prove financially successful. In order that the manufacture of beet sugar should become an established commercial success, the factories and the farmers must work in harmony. The method pursued in France and in Germany would probably be best suited to bring about this result. In those countries the beet growers themselves are usually shareholders in the factories, and thus participate in the profits. It is probable that the average dividend of German and French beet-sugar factories would not fall much

below 20 per cent net on the capital invested. The farmer, therefore, who has even a small interest in such a factory secures a handsome profit on his invested capital. At the same time he has a vote in the board of directors and is personally interested in the success of the factory. In many factories of Europe the stock is thus held by the beet-growers. If, on the other hand, the whole of the factory be owned by the capitalists, then there is a cause for continual conflict between the interests of the farmer and the interests of the manufacturer, although this conflict is perhaps more in theory than practice. Even if the factory be owned exclusively by the capitalists, it is to their interest to work in harmony with the farmers, in order that they may secure a crop of sufficient magnitude to render the operation of their factory profitable.

It perhaps, however, would be unavoidable at the beginning of the industry that a feeling of animosity should exist between the beet-grower and the manufacturer. After a few years the prices to be paid for beets, and other arrangements with the farmers will doubtless be adjusted on a scale of equity and satisfaction to all concerned. In case farmers have no money to put into beet-sugar factories they might take shares of stock and pay for them with beets during the first and second years; in this way they would secure a financial interest in the company, own their shares of stock, and pay for them from the proceeds of the field without investing in ready cash. By adopting some such plan as this it might be possible to get every beet-grower within reach of the factory to become interested as a stockholder.

ANALYTICAL DATA COLLECTED FROM VARIOUS LOCALITIES WHERE BEETS WERE GROWN FROM SEED FURNISHED BY THE DEPARTMENT.

The samples of beets which were sent to the Department in response to the request already noted were immediately analyzed and the results of the analyses communicated to the growers of the beets. These data have been tabulated by States and by counties in States, and will be printed in detail in Bulletin No. 29 of the Chemical Division. Returns were received from a great many States, but principally from Nebraska and Minnesota. A brief summary of the results obtained follows:

Two samples were sent from Missouri, from Bates County. These were of poor quality, containing only 8.4 per cent of sugar, with a purity of 66.8. The beets, however, were of good size, averaging 600 grams (100 grams are equivalent to 3.53 ounces). Two samples of beets were received from Texas, Scurry County. These beets were of better quality than those from Missouri, containing 10 per cent of sugar, with a purity of 69.3. They were, however, very much too large for first-class sugar beets, averaging 1072 grams in weight. One sample of beets was received from Idaho, from Ada County. This sample contained 8 per cent of sugar, with a purity of 68.3, while the beets were extremely small, averaging only 100 grams. Six samples were received from Massachusetts, five from Hampshire County, containing 11.2 per cent sugar, with a purity of 82.8, the average weight of the beets being 468 grams, and one from Suffolk County, containing 16 per cent of sugar, with a purity of 82.8, and weighing 350 grams. Four samples of beets were received from California, Los Angeles County. These contained an average of 14.7 per cent sugar, with a purity of 84.6 and a mean weight of 382 grams.

In order to secure brevity the data obtained for the other States and the localities where the beets were grown have been compiled in the following tables:

State and county.	No. of samples.	Per cent of sugar in the beet.	Purity coefficient.	Average weight in grams.
Connecticut:				
Litchfield	2	9.7	76.1	400
Maryland:				
Prince George's	81	12.3	79.7	416
Oregon:				
Jackson	2	15.1	73.4	560
Washington:				
Lewis	1	15.2	84.2	450
Virginia:				
Augusta	19	11.4	76.3	415
Loudoun	2	5.4	53.7	480
Pennsylvania:				
Dauphin	2	8.4	76.7	1,209
Lancaster	7	7.5	72.8	566
Philadelphia	1	10.04	75.2	1,225
Wyoming:				
Carbon	2	12.3	78.8	1,213
Crook	1	16.3	.....	260
Laramie	2	17.3	84.8	508
Illinois:				
Kendall	1	6.5	64.8	832
Pike	1	10.2	71.8	1,368
Platt	1	6.1	61.0	685
Will	4	11.9	75.8	830
New York:				
Genesee	3	12.2	79.4	1,732
Oneida	2	11.1	78.8	423
Warren	2	13.8	84.5	643
Yates	3	11.4	71.7	470
Wisconsin:				
Calumet	3	11.9	81.9	705
Kewaunee	2	13.5	79.6	632
Ozaukee	2	12.7	81.5	505
Vernon	3	13.8	81.6	493
Ohio:				
Butler	1	9.2	76.4	1,017
Erie	1	8.8	71.5	305
Hamilton	1	12.4	80.9	458
Sandusky	3	12.3	76.9	935
Trumbull	7	9.6	77.9	808
Van Wert	2	6.2	67.3	370
Colorado:				
Garfield	1	13.00	74.1	405
Larimer	7	14.00	83.2	644
Mesa	1	14.40	86.4	453
Phillips	3	12.90	71.9	638
Prowers	5	9.80	68.8	519
Pueblo	6	12.80	79.2	578
San Miguel	2	9.90	65.8	820
Yuma	2	9.90	69.5	573
South Dakota:				
Brookings	7	14.4	84.9	472
Brown	1	16.3	80.4	295
Davison	2	12.6	72.3	806
Grant	1	11.0	73.0	856
Hyde	4	13.0	78.8	619
Kingsbury	2	10.5	71.1	553
Meade	2	14.1	74.2	765
McCook	2	10.6	76.4	365
North Dakota:				
Burleigh	1	10.4	70.3	453
Cass	5	13.0	75.5	736
Dickey	2	11.0	70.4	1,060
Morton	1	13.8	73.9	508
Nelson	1	13.6	74.1	675
Ransom	4	10.3	71.3	794
Sargent	2	20.8	.....	218
Stutsman	1	12.5	77.6	570
Traill	7	14.7	76.7	701
Kansas:				
Barber	3	14.7	80.0	363
Bourbon	3	9.3	73.3	1,403
Butler	1	9.7	70.5	685
Kansas—Continued.				
Clay	4	9.3	67.6	611
Douglas	2	8.4	65.1	1,175
Hamilton	2	12.6	76.8	750
Johnson	2	12.4	68.4	295
Lyon	2	4.4	50.6	2,423
Saline	2	7.9	63.2	889
Stafford	1	11.5	75.2	548
Iowa:				
Audubon	1	10.7	74.9	535
Black Hawk	6	12.8	78.2	578
Carroll	6	12.8	78.2	578
Cherokee	2	10.4	68.2	474
Fayette	2	11.3	75.7	750
Harrison	2	10.8	73.1	1,013
Page	1	11.1	72.6	668
Polk	2	8.0	56.0	355
Sioux	3	11.6	72.7	788
Webster	4	14.4	84.8	560
Woodbury	2	9.7	67.0	628
Michigan:				
Clinton	2	11.5	77.2	763
Eaton	2	9.1	.....	187
Gratiot	4	12.3	75.7	1,018
Huron	1	11.1	74.7	1,282
Ingham	1	12.5	76.6	1,515
Ionia	2	15.2	82.9	415
Lenawee	2	8.0	60.5	2,193
Macomb	2	15.4	87.5	693
Muskegon	11	12.2	80.9	699
Saginaw	2	12.9	82.0	773
St. Clair	1	10.0	71.5	1,660
Indiana:				
Benton	19	12.0	80.0	697
Cass	6	12.4	71.9	625
Clinton	1	18.1	78.9	430
Decatur	1	5.3	58.9	1,840
Grant	5	8.6	70.3	701
Greene	2	13.4	77.9	303
Hamilton	2	10.2	69.7	506
Hancock	2	6.9	51.8	718
Henry	1	10.6	82.6	780
Howard	1	13.2	70.5	600
Marion	6	9.8	65.6	548
Montgomery	2	7.7	64.4	953
Newton	2	10.0	71.7	543
Pike	1	10.5	75.7	432
Tippecanoe	2	8.3	64.6	603
White	3	8.2	63.3	543
Minnesota:				
Anoka	10	12.6	76.7	637
Becker	3	12.2	73.7	1,410
Blue Earth	8	10.5	74.1	684
Brown	2	8.5	68.1	1,158
Carver	4	11.0	71.1	951
Chisago	5	12.9	79.9	923
Clay	2	13.0	75.2	765
Cottonwood	2	12.3	67.7	898
Dakota	2	14.6	81.1	367
Faribault	2	9.8	64.6	873
Fillmore	2	11.4	74.6	826
Goodhue	6	10.9	71.1	685
Hennepin	6	12.4	77.8	1,216
Houston	1	13.0	80.6	510
Isanti	3	10.0	70.5	1,623
Le Seuer	2	10.8	73.2	508
Lincoln	2	12.3	73.2	1,343
Lyon	2	14.9	78.2	490
Marshall	1	8.5	66.9	740
Martin	7	11.2	73.5	889
McLeod	2	10.9	73.7	943
Meeker	2	11.0	75.0	525
Murray	5	15.2	84.4	415

State and county.	No. of samples.	Per cent of sugar in the beet.	Purity coefficient.	Average weight in grams.	State and county.	No. of samples.	Per cent of sugar in the beet.	Purity coefficient.	Average weight in grams.
Minnesota—Continued.					Nebraska—Continued.				
Nicollet	1	13.0	75.6	612	Hall	2	16.1	88.8	423
Nobles	2	13.1	76.4	1,268	Hamilton	2	13.3	.....	235
Pipe Stone	2	11.0	71.0	1,154	Harlan	4	10.7	68.8	328
Ramsey	12	10.6	81.0	830	Hayes	3	14.2	74.5	913
Rock	1	13.5	79.3	870	Hitchcock	4	14.0	73.0	464
Steele	2	9.3	67.6	1,043	Holt	17	13.5	73.9	777
Traverse	2	17.0	76.3	708	Howard	1	11.9	79.6	810
Wabasha	1	9.8	71.0	280	Jefferson	7	11.8	72.4	434
Washington	3	10.6	76.4	1,103	Kearney	3	20.2	76.1	224
Wilkin	1	14.6	80.6	447	Kimball	1	10.8	70.4	227
Wright	1	10.0	71.4	910	Knox	5	10.7	71.4	868
Nebraska:					Lincoln	9	12.5	75.0	613
Antelope	29	12.5	74.7	419	Loup	2	9.6	66.0	692
Banner	3	11.4	70.4	612	Madison	5	11.6	74.7	523
Blaine	2	12.6	76.3	580	McPherson	2	12.4	76.2	238
Boone	36	10.1	69.2	550	Nuckolls	4	8.5	67.4	347
Box Butte	6	12.2	71.6	666	Pawnee	4	12.7	80.5	693
Brown	1	10.1	69.7	350	Perkins	7	12.4	74.9	857
Butler	2	12.7	68.9	245	Phelps	5	12.4	70.2	305
Chase	8	11.7	70.6	796	Pierce	1	10.9	75.2	565
Cherry	2	8.9	60.5	530	Platte	4	10.0	68.3	369
Colfax	7	11.8	71.3	661	Polk	3	10.9	68.4	533
Cuming	2	10.4	69.8	692	Red Willow	2	8.1	61.2	940
Custer	4	7.0	58.2	550	Richardson	5	9.8	65.4	733
Dawes	3	12.7	73.3	258	Rock	1	14.4	83.1	400
Dawson	2	10.5	73.3	670	Saline	2	7.8	60.1	425
Deuel	1	18.8	....	248	Saunders	4	13.1	75.8	559
Dodge	2	14.8	82.3	600	Scott's Bluff	1	22.7	83.3	333
Dundy	1	10.0	67.7	1,565	Seward	2	11.2	72.3	450
Fillmore	5	11.6	68.7	677	Sheridan	9	11.2	69.8	503
Frontier	7	12.3	74.4	531	Thayer	13	14.6	77.8	632
Furnas	5	12.7	76.0	454	Valley	2	10.6	69.7	503
Gage	6	9.4	68.6	721	Wayne	2	9.0	70.8	413
Garfield	6	15.4	74.8	533	York	9	12.9	72.4	443

In the above summary of the beets sent from Nebraska are not included those which were examined at the Grand Island Sugar Factory under the direction of the Chemical Division, but only those which were sent directly to the Department at Washington for examination. In addition to these two sets of analyses large numbers of samples were examined in the laboratory of the Agricultural Experiment Stations at Lincoln and Madison, Wisconsin.

In a critical study of the summary given above there are many points of interest, a few of which only can be given here, while the others will be given at greater extent in Bulletin No. 29. In judging of the character of a beet for sugar-making purposes three factors must be taken into consideration. First of all, the beet must be large enough to make its growth profitable to the farmer. Experience has shown that a beet which weighs about 500 grams, that is, a little over 1 pound, is best suited to secure the interests of both the farmer and the manufacturer. Therefore, in all cases attempts should be made to grow beets as uniformly as possible of that weight. Having once established the average weight of the beet, the next point to be considered is its content in sugar. In the data given the percentage of sugar is reckoned on the weight of the beet itself and not upon the extracted juice. Sugar beets contain on an average about 5 per cent of marc and 95 per cent of juice. Therefore if the analysis is made upon extracted juice, the number obtained must be multiplied by 0.95 to give the percentage of sugar in the beet.

The question may arise as to how poor a beet can be in sugar and

still be profitable for sugar making. This of course is a question which has to be determined by a comparison with many economic problems, the study of which can not be introduced at the present time. In general, however, it may be said that the limit of profit in manufacture will be reached when the percentage of sugar in the beet drops to 12, although it is possible under certain conditions for factories to work economically and profitably on beets having a lower percentage of sugar than that indicated.

With the present degree of perfection in the production of rich sugar-beet seed, and with the knowledge of the scientific principles of agriculture which should guide the beet grower, it is possible, I think, to show that beets can be produced, under favorable soil and climatic conditions, which will contain on an average 14 per cent of sugar. The farmer, therefore, should not be satisfied if his results fall below this standard.

It will be easy to see by comparing the averages given in the above table how many of the beet growers have succeeded in growing plants which will average 500 grams in weight and contain 14 per cent of sugar.

In addition to these two factors, however, a third must be taken into consideration, namely, the purity of the juice. By the purity of the juice, or, as it is expressed in the table, the coefficient of purity, is meant the percentage of pure crystallizable sugar in the solid bodies present in the juice. For instance, if in 100 parts of solids there are 80 parts of pure crystallizable sugar, the coefficient of purity of that juice is said to be 80. The number 80 may be taken as a fair average which should be attained in this country. In the older beet-growing countries a much higher degree of purity can be obtained than this. The degree of purity of the juice is influenced chiefly by the amount of salts represented by the ash obtained on the ignition of the sample. In soils highly impregnated with mineral substances, such as are often found in our western States, the percentage of ash will be found very high, and there will be a corresponding depression of the purity coefficient. In lands, however, which have been long cultivated and scientifically treated from an agricultural point of view, the percentage of ash in the beet will be diminished and the purity coefficient correspondingly raised. The ash of the beet consists largely of phosphoric acid and potash, and these two substances are essential to the proper growth of the beet. It is therefore not expected that the ash of the beet shall be reduced below a certain content, otherwise the growth and maturity of the plant will be retarded. It will not be possible in the space which is at our disposal here to discuss each of the series of data obtained by these analyses, but the above remarks are made for the purpose of enabling anyone who is interested in any particular series or analysis to discuss it intelligently and determine from the numbers given the value of the beets produced for sugar-making purposes. At the present time, for the purpose of fixing a standard of comparison, I would say that the typical sugar beet for sugar-making purposes should weigh 500 grams, contain 14 per cent of sugar, and have a purity of at least 80. With such raw material at his disposal in sufficient quantity, the manufacturer can not fail of success, provided he be supplied with the latest and most improved forms of machinery.

It may also be of interest in connection with the data above given to discuss some of the particular qualities of the beet separately. In general the mistake is made by those not acquainted with the princi-

ples of the growth of the sugar beet and manufacture of beet sugar of judging of the possibilities of success by the percentage of sucrose in the beet alone. The danger of relying solely upon this constituent of the beet is at once manifest from the considerations above mentioned. Nevertheless as it is often done, I have collected into tabular form from the analyses given above all of the results showing from 15 to 18 per cent of sugar in the juice. In another table have been collected all the analyses in which more than 18 per cent of sugar was found. In the case of Minnesota 3 samples of beets were found in which the percentage of sugar was more than 18; in the State of Indiana, 1 sample; in Iowa, 1; in North Dakota, 4; in Maryland, 5; in Colorado, 1; in Wyoming, 1; in Nebraska, 13. Of beets showing a percentage of sugar from 15 to 18 in the juice, the following numbers of samples were found: In Illinois, 3; in Minnesota, 15; in Nebraska, 36; in Maryland, 8; in Iowa, 4; in Wyoming, 2; in Colorado, 9; in North Dakota, 4; in Massachusetts, 1; in Wisconsin, 2; in California, 2; in South Dakota, 6; in Michigan, 4; in Kansas, 3; in Washington, 1; in Oregon, 2; in Virginia, 2.

The production of beets containing from 15 to 18 per cent of sugar is not unusual, and such beets may be regarded as strictly normal in constitution, but possessing a particularly high content of sugar. When, however, the content of sugar in the beet exceeds 18 per cent it must be regarded at the present time as something abnormal and due to peculiar conditions affecting the particular locality, or even the particular plant itself. Such beets are usually extremely small in size, and the richness of their sugar content has been acquired at the expense of normal growth. In other cases the effect of a particularly dry season preceding the time of harvest or other very peculiar conditions may affect the sugar content. In many other cases, from the wilted condition in which the beets have been received, it must be admitted that a portion of the water which they contained has dried out between the time of harvest and the time of analysis, thus increasing the apparent percentage of sugar in the beet. It will doubtless be possible hereafter, when the beet has been more fully developed by careful selection, to produce beets normally which contain more than 18 per cent of sugar, but to expect at the present time the production of such beets on a large scale would be unreasonable, and such an expectation would not be realized. Even when we consider the other class, namely, those containing in their juice from 15 to 18 per cent, we must confess that it would be unwise to look for a production of beets on a large scale containing so large a percentage of sugar. In many of the cases of beets of this class the high-sugar content must be ascribed primarily to some of the conditions mentioned for the class above 18.

When, however, the tables are further studied and the remarkably low percentages of sugar are noticed which were sometimes found, it must be confessed that in these cases the abnormally low content of the sugar is also due to the abnormal growth of the beet. In some cases these beets are of great size, weighing 2,000 grams or over, and to this extraordinary growth must be attributed to a certain extent the low content of sugar. In general, it has been found that when beets exceed 500 grams in weight it is difficult to maintain their sugar content at a high standard. When, therefore, the beets become greatly overgrown it is always accompanied with a

falling off in content of sugar. In the cases, however, of the small beets, which have shown a low content of sugar, the result must have been due to defective conditions of soil and climate, or to defective methods of planting and cultivation, or to premature harvesting.

When we consider the varying qualities of beets which have been grown from the same seed, we are at once struck with the immense importance of the factor of soil and climate and cultivation in the production of the sugar beet. The fact that the seed of the Klein Wanzlebner variety of beet in the hands of different farmers will show a variation of from 6 to nearly 20 per cent of sugar, it must be confessed that we have in soil and climatic conditions, and in methods of cultivation, a more potent means of influencing the sugar content of the beet than is found in the germ of the seed itself. It can only be expected that a sugar-beet seed which is high bred will be able to reproduce its kind when it has become fully acclimated and has received in its new condition the same scientific treatment and selection which it had in its original home. The great hope, therefore, of uniform production of sugar beets high in sugar-producing power in the United States must be found in the establishment of culture stations, where different varieties of beets can become fully acclimated, and where they can receive the same careful scientific culture and selection which have brought them up to their present state of excellence in Europe.

CHARACTER OF BEETS DELIVERED TO THE GRAND ISLAND FACTORY.

Through the courtesy of Mr. H. T. Oxnard the Department was allowed to establish a laboratory at the sugar factory at Grand Island for the purpose of obtaining information in regard to the character of the beets entering into manufacture. In all about three thousand samples of beets were examined, a sample having been taken from every wagonload and every carload of beets delivered to the factory. These samples were taken in such a way as to give as nearly as possible the average character of all the beets worked. A large number of beets was taken from each sample, and after they had been properly cleaned and dried their average weight was taken. The beets were then rasped, the juice expressed, and an analysis made on the expressed juice. The total solid matter was determined by a specific-gravity spindle, and the percentage of sucrose in the juice was estimated by the polariscope. The purity coefficient was determined by dividing the percentage of sucrose in the juice as indicated by the polariscope by the percentage of total solids as indicated by the spindle.

Average weight of beets.—The average weight of all the beets examined was 200 grams. This small size of the beet was doubtless due to the extremely dry season. The drought throughout the region covered by the sugar-beet fields was the most severe perhaps that has ever been known in the State of Nebraska. Ordinary crops such as corn were almost total failures, and it is a matter of encouragement to note that in such a season the beets, although not making an average yield, yet did fairly well. On the whole, however, it must be confessed that the results from an agricultural point of view were disappointing; but this disappointment must be chiefly attributed to the exceptionally severe drought already mentioned.

It is also doubtless true that in the practice of the new system of agriculture which is required for the proper production of sugar beets many failures were made, and perhaps very few of the farmers practiced that form of agriculture which was best suited to the soil and the season. In a soil which is apt to be dry as in Nebraska too much attention can not be paid to the importance of loosening the ground to a good depth. Deep plowing followed by deep subsoiling, together with such harrowing and other treatment of the surface as will produce a perfect tilth, are absolutely essential to the production of a profitable crop.

The remarkably high percentage of sucrose shown in the juice is an evidence of the fact that the soil and climate of Nebraska are favorable to the production of a beet rich in crystallizable sugar. It must, however, not be forgotten that the extremely high percentage of sucrose in the juice is probably a reciprocal of the small size of the beet due to the dry season. Had the season been favorable to the production of a beet of average size, with a tonnage of from 15 to 20 per acre, the percentage of sucrose in the beets would doubtless have been less. This is well illustrated in the data obtained in the Department from the analysis of sugar beets sent from Nebraska. It is evident from the character of the samples which were received by the Department that the farmers have selected the larger beets to be sent on for analysis. It is seen by comparison of the respective sizes of the beets received for analysis by the Department with those received for manufacture at Grand Island that the beets sent on for analysis were about three times the size of those manufactured into sugar. It will also be noticed that in the beets received for analysis by the Department the percentage of sucrose is low as compared with those which entered into manufacture at Grand Island. It would therefore hardly be just to claim that beets as rich as those manufactured at Grand Island during the past season can be grown in quantities of from 15 to 20 tons per acre. It is not a matter of surprise that many of the farmers who grew beets are discouraged at the results of the first year's work. The planting and cultivation of the sugar beet as is well known are matters which require great labor and expense, and when, therefore, an unfavorable season cuts the crop very short, it is but natural that the farmer should be discontented. It is, however, difficult to see how he could have done better with any other crop, and the fact that in many instances even with the present dry season the farmers of Nebraska were able to grow 10 or even 15 tons per acre, shows that with proper cultivation and proper attention in other ways to the growing crop the evils which attend a severe drought can be greatly mitigated if not altogether avoided. It is not the purpose of the Department to encourage farmers to engage in an industry which does not give promise of success; but it will be a matter of regret to every one who desires to see the success of the sugar industry if the discontent which naturally attends a very unfavorable season should be sufficient to deter farmers from continuing the cultivation of a crop which under ordinary conditions promises so fair a yield as sugar beets. It would be wiser on the part of the farmers to continue the cultivation of the sugar beet until it has been demonstrated at least that even with favorable years it is not profitable. In that case it would be perfectly justifiable in the farmers, of course, to cease the cultivation of a crop which afforded no prospect of financial success.

EXPERIMENTS WITH SUGAR BEETS AT MEDICINE LODGE.

In addition to the analyses and control of the sorghum sugar work extensive examinations were made of the beets growing in the locality of Medicine Lodge.

The season was a peculiar one for beets. At the commencement of the rains, on the 28th of August, the beets were scarcely at all developed and were regarded as a total failure. After the rains commenced the beets grew rapidly and continued to grow vigorously through the months of September and October. About the middle of November the harvesting of the beets was commenced and continued until December. At that time the beets had reached a fair size and developed a high content of sugar. Two hundred and sixty-one wagonloads were brought to the factory and large samples were taken from each of these loads and subjected to analysis. The means of two hundred and sixty-one analyses follow:

In the juice.

Total solids..........per cent..	18.52
Sucrose..........do....	15.12
Purity..........	81.04

Four hundred and eleven miscellaneous analyses of the beets from different plots in the vicinity of Medicine Lodge were made with the following mean results:

In the juice.

Total solids..........per cent.	17.80
Sucrose..........do....	13.20
Purity..........	75.60

The fresh chips entering the battery had a mean sucrose content, in the juice, of 13.90 per cent, much less, as will be noted, than that represented by the analyses from the different loads.

The diffusion juices show a content of 10.45 per cent sucrose and a purity of 81.2.

The working of the beets with the sorghum-sugar machinery was extremely slow, and either from this cause or from the method of liming, which was very heavy without any subsequent use of carbonic acid, the clarification and boiling of the juices became a matter of great difficulty, and they suffered in this process rapid deterioration; for instance, the purity of the clarified juice was only 78.8 and of the sirup 78.3, while the mean purity of the massecuites showed the enormous depression represented by the difference between 78.8 and 59.4. The actual cause of this remarkable deterioration in boiling is not well understood, and the juices boiled with the greatest difficulty, it being almost impossible to prevent them from foaming in the pan. The semisirups also, after standing for a time, deposited a large quantity of mucus or viscous material, and this would lead to the supposition that a pernicious fermentation of a viscous or mannitic nature was the cause of the great loss of sugar during the boiling operations.

It is evident at once that the attempt to make beet sugar without appropriate apparatus must be regarded as futile. Beets of the quality of those delivered at the Medicine Lodge factory, if they had been properly and promptly manufactured, would have yielded almost 250 pounds of sugar to the ton; instead of this the yield was

extremely small, the separation from the massecuite very difficult, and the whole manufacturing process disappointing.

In regard to the probability of producing beets in the locality of Medicine Lodge, I am still of the opinion, expressed in Bulletin No. 27, that it is a locality too far south to expect the successful culture of the sugar beet. In using the term "too far south" it is not meant in an absolute sense, but too far south from the zone of the probable beet industry as indicated in the map given in Bulletin No. 27. The actual growing season at Medicine Lodge it will be noticed was not during the summer, but in the autumn after the rains fell and the weather had become cool. Had the early part of the season been wet enough to secure a growth of the beets it is hardly probable that they would have shown the high content of sugar which they did. The splendid results obtained at Medicine Lodge in the working of sorghum cane would seem to indicate the course which the sugar industry should follow in that locality. Everything indicates that the culture of sorghum sugar will prove a success while there is little to encourage the further development of the beet-sugar industry in that locality.

PRODUCTION OF SEED.*

There is, perhaps, no other agricultural crop which has illustrated in so marked a manner the importance of seed selection as the sugar beet. By the careful selection of those variations in the original beet which seemed most favorable to the production of sugar, and the careful selection of beets in the production of seed during the succeeding year, and by judicious and scientific fertilizing for the purpose of increasing the sugar content, there has been a great evolution in the sugar-producing power of the beet which has placed it at the head of the sugar-producing plants of the world.

The influence of the quality of the seed, according to Vilmorin, is absolutely predominant from the point of view of the results obtained in the culture of the sugar beet. The numerous experiments of scientific investigators have shown that remark to be true. In France the firm of Vilmorin-Andrieux & Co. has paid special attention to the improvement of the standard varieties of the sugar beet by the method above mentioned. They have endeavored to produce different varieties of beets of which each one would have all the possible advantages in the different economical and culture experiments to which manufacturers and farmers will submit them.

It is true, without doubt, that the same variety of beet could not be the most advantageous in every case, and that, according to the results to be obtained, it might be an advantage in one place to cultivate a variety extremely rich and in another place one, which, while still rich in sugar, would also produce a heavy yield in pounds. To these different needs different varieties of beets respond. In one case the pure white variety, in another the white variety with green neck or the rose variety with rose neck, or the Vilmorin Improved, a variety which is suitable everywhere and particularly in those countries where the duty on beet sugar is laid directly on the beet. Since the introduction of the new law in France, in 1884, levying the tax upon the actual weight of beet produced, the White Improved Vilmorin beet has recommended itself by its exceptional richness, its great purity, and the ease with which it can be preserved. But in order to meet all the conditions necessary to the greatest success

*Bulletin No. 27, Division of Chemistry, pp. 41–46.

it is essential to find out by experiment that variety of beet, which, in any given locality, fulfills most of the conditions required to produce a high yield of sugar with a minimum cost and one which will be equally profitable to the farmer and manufacturer.

At the present time, it is necessary in this country to go abroad for beet seed of the highest character. Up to the present time the sugar-beet seed which has been grown in this country has been produced without especial reference to the conditions necessary to maintain the beet at a high standard and to improve it as is done in foreign countries. In other words, the sugar-beet seed which one will obtain from American dealers, if it should be that which is grown at home, does not come with the pedigree of the beet, in regard to content of sugar and purity of juice, nor with that assurance of care in cultivation which the professional producers of beet seed in foreign countries bestow upon their work. There is no reason, however, to suppose that it is impracticable to produce beet seed in this country of as high a grade and of as pure a quality as that which can be obtained in other countries. The method of doing this will be briefly indicated.

In growing the beets the greatest care should be taken to secure all the conditions necessary to produce a beet of maximum richness in sugar, coupled with a yield per acre of fair proportions. This can be done by attending to the directions for culture to be given, combined with judicious application of those fertilizers which will tend to increase the sugar content of the beet without unduly increasing its size. The fertilizers which are most suitable for this purpose are carbonate of lime, when it is not present in sufficient quantities in the soil, a small quantity of magnesia, and larger quantities of phosphoric acid with varying proportions of potash and nitrogen, according to the character of the soil in which the beets are grown. No certain rule can be given for the application of fertilizers until the conditions of the season and the character of the soil in each particular locality have been carefully studied experimentally. For this reason, it is certain that in this country, as in others, the business of producing beet seed will be one entirely distinct from that of raising beets for manufacture or from the manufacturing thereof. It is this business which will require not only the highest scientific agriculture but the most careful agronomic skill.

SELECTION OF "MOTHERS."

The beets which are to be used for producing the seed should be selected on account of the possession of those properties which are most suitable to secure the highest results in the production of sugar. In the first place, all beets of irregular or unwieldly shape should be rejected; those selected should be of uniformly even texture, smooth outline, and symmetrical shape.

The sugar content of these beets should be determined by the analysis of others grown in the same plot and of the same seed, and thus obtain the average content of sugar for the whole lot. Only that class of beets showing the highest content of sugar combined with the qualities given above, and the greatest purity of juice, should be preserved. In many cases the beets themselves, which are to be used for propagation of seed, are subjected to analysis by the removal of a cylindrical section by an instrument provided for that purpose and the analysis of this section. In this way the actual sugar content of

the beet which produces the seed can be obtained. It is said that good results have also been secured by replacing the portion of the beet removed by sugar at the time of planting, which will afford an additional food product for the earlier growth of the beet in its second year.

Another method of selecting the beets, which has been widely employed, is that of determining their density. A solution of some substance is made in water, such as salt or sugar, of such density as to permit beets of inferior quality to float on the surface and those of superior quality to sink. These heavier beets, other things being equal, contain larger quantities of sugar and are more suitable for the production of seed. The beets, of course, which are to be used for the production of seed must be very carefully harvested so as not to be bruised, leaving the roots as much as possible uninjured, and they must be carefully preserved in silos over the winter until the time for transplanting in the spring. The transplanting and the successful cultivation of the beets need no detailed description.

The character of the beet is also sometimes determined by removing a small portion, as indicated above, for polarization, expressing the juice and determining its specific gravity by weighing in the juice a silver button of known weight.

The absolute necessity of securing a few beets of the highest sugar coefficient and purity for the purpose of producing a crop of seed in third, fourth, or fifth year, according to the number selected, has in the last few years been recognized to a degree unknown before. At first it was the custom to select the beets, by some of the methods mentioned above, in large numbers sufficient to grow in the second year seed for the market. A much more rational method, however, and one which secures higher results, consists in a more careful selection of the mother beets for the purpose, not of producing seed for the market in the second year, but only for the purpose of securing an additional crop of beets in the third year which in the fourth year will produce seed for the market. The methods employed by different seedsmen vary somewhat, but the principle in all cases is the same. The general method may be indicated by that pursued by Dippe in Quedlinburg:*

First year.—Seed planting for mother beets, from seed which came from the highest polarizing beets of different varieties, which have, of course, been kept separate. The planting is in rows 18 inches apart, and the plants are cut away in the rows so as to stand 10 or 12 inches apart. At the time of harvesting the beets are selected out according to form, growth, and leaf formation, as these best approximate the characteristics of the parent variety.

Second year.—In March and April these selected beets are examined in the laboratory † in the following manner:

At a certain point which it is presumed will give an average of the entire beet, a cylindrical piece is cut out, subjected to strong pressure in a juice press, which will give, for example, from 17 grams of beet 10 grams of juice, of which 5 cubic centimeters are diluted with lead acetate and water to 25 cubic centimeters, filtered and polarized. For the different varieties minimum limits are established, and the beets are arranged in three classes according to their polarization:

First, beets which go below the limit and are thrown out; second,

* Stammer, pp. 200, *et seq.*, Lehrbuch der Zucker Fabrication.

† This is not done until spring in order that only well-preserved beets may be chosen.

beets which are above the limit, and fairly good for seed purposes, and, third, beets which show an extra high figure.

These extra good beets are now examined still further, two more cylinders taken out, and the sugar estimated by the extraction method. From this result and the estimation of the sugar in the juice the (apparent) content of juice is calculated. Those beets which do not reach a standard, established for each variety (between 92 and 94), are thrown out, while those that attain it are the chosen "mother beets" of the crop, which are to perpetuate the variety, and which furnish the seed for each new succession, as mentioned in the first paragraph.

In the second year are planted all the beets saved, the extra and medium as well; the former furnish seed for extra mother beets, which are used as indicated for the normal-sized mother beets which furnish seed for a new succession, while the latter are to produce a generation of dwarfs, the seed from both being saved.

Third year.—The seed from the medium and extra mother beets is planted, and the latter produce the mother beets for future breeding purposes, as indicated, but the plants from the former seed, which was planted a little later than would be the case for beets ordinarily, and in soil fertilized with ammoniacal superphosphate and also some guano, in rows 12 inches apart, are cut out to about every 3 to 5 inches. The small beets are very carefully preserved under a thick covering of earth. In the spring of the

Fourth year.—They are uncovered and planted at about 26 to 24 inches apart. The seed from these when harvested in the fall is ready for the market, so that it has taken five years to attain this end.

In the establishment of Branne, in Biendorf, the procedure is similar, but the beets are selected by their specific gravity in the field. A woman sits at a table and cuts from each beet a very small piece and throws it into a solution of salt of known density (for example, with the Klein Wanzleben, 16° Brix). If the piece of beet floats, the corresponding beet is thrown away, but if it sinks the beet is reserved for further investigation in the laboratory. The beets chosen in this way are submitted to further selection by the examination of the juice from a cylinder.

In a somewhat different way, but still by means of the examination of individual beets, is the culture of the Klein Wanzleben variety carried on by Rabbethge, in Klein Wanzleben, whose object is not so much to furnish establishments with all the seed they require for planting, but rather with seed for the production of mother beets, and their own seed from these. The fact that Klein Wanzleben has never yet harvested more than 3 tons of seed in a season indicates the character of the work, which is much to be commended.

The seeds are always taken from mother beets of considerable weight, never from small or dwarf beets, and the aim is not so much to produce individual beets of exceptionally high sugar content, but large beets as well; that is, beets which give the highest yield of sugar from a given amount of land. These roots, which are chosen from a field of the best (Elite) beets, and which possess most distinctly the characteristics of the variety, are weighed and their juice polarized, and this operation is continued until 20,000 beets are chosen which fulfill the requirements as to weight and sugar content.

These 20,000 best mother beets are sufficient to furnish the planting

of a hectare (2½ acres), and from them are obtained 40 to 60 hundred weight of the best (Elite) seed, and this gives the following year 60 to 100 hectares of the best (Elite) beets, or 5,000,000 to 7,000,000 plants. From these are finally chosen the 1,500,000 seed-bearers which furnish the planting of 100 hectares and the seed for sale and for the perpetuation of the breed.

An entirely different method of selection is what is known as "family" breeding. Hundreds of specially selected beets, excellent in every way, are planted out separately. The seed of each is gathered and planted separately. If among the beets thus obtained any are found that excel the mother beet in every respect, and this improvement endures through several generations, these are incorporated with the other mother beets and used for breeding. As examples of weight and polarization of the selected beets the following figures for the highest and lowest weights are given, representing the best mother beets of the years 1883 and 1884:

Weight.	Sucrose in juice.	Weight.	Sucrose in juice.
Grams.	*Per cent.*	*Grams.*	*Per cent.*
1,550	11.24	600	15.11
1,450	13.68	600	16.28
1,250	14.29	600	16.28
1,500	15.87	400	16.13
1,450	14.60	550	15.62
1,700	11.76	400	16.83
1,860	14.86	550	16.88
2,100	14.35	400	16.63
1,900	14.60	600	15.63
600	16.13		

Among 200 beets were found only 11 with a weight of less than 500 grams; 12 with a weight of 500 to 600 grams; 29 with a weight of 600 to 700 grams; 21 with a weight of 700 to 800 grams; and finally 127, or 63 per cent, with a weight of over 800 and up to as high as 2,100 grams.

The beets between 700 and 1,000 grams are of nearly identical sugar content, a peculiarity of the Klein Wanzleben variety.

The established normal weight varies, according to the season, between 600 and 900 grams; in the year 1883 it was 897 grams, corresponding to the average of the beets from a field.

A still different method is followed by v. Proskowetz (Kwassiz). The beets from which selections are to be made are placed in a solution of salt showing 17.5° Brix, and those which float are used as fodder; those which sink are analyzed for sugar content by the alcohol extraction method, for which purpose a small quantity, half the normal weight, is cut out with a rasp and polarized in a 400-millimeter tube. Beets which give at least 19 per cent of sucrose form the first class; those showing 18 to 18.9, inclusive, the second, and those from 16 to 18 the third Beets under 16 per cent are used for fodder.

METEOROLOGICAL CONDITIONS.*

In addition to suitable soil, fertilizing, and cultivation the sugar beet requires certain meteorological conditions for the highest production of sugar. Temperature and rainfall exercise the most

* Bulletin No. 27, Division of Chemistry, pp. 169–177.

pronounced influence, not only on the yield of beets but also on their saccharine qualities.

A mean summer temperature of 70° Fahr. for ninety days is sufficient to push the beet well on to maturity, while a much higher degree than this tends to diminish its saccharine strength.

The experience of beet growers in California indicates that in certain latitudes the beet can flourish with a much less rainfall than has hitherto been deemed a minimum for its proper growth; but this is not conclusive evidence that in all localities so small a supply of moisture would be sufficient. In regions of dry and hot winds, or where the subsoil is less porous, or aerial evaporation much more vigorous, less favorable results would be obtained. Dr. McMurtrie traced his area of beet-sugar limits with an isotherm of 70° Fahr. for the summer months, and a minimum rainfall of 2 inches per month for the same period. By the kindness of the Signal Office I have obtained a record of mean temperatures and precipitation for each month in the year for a period of ten years of those portions of the country in which the culture of the sugar beet is most likely to succeed. Also from the same source a tracing of the mean isotherm of 70° Fahr. for ten years for the three months of June, July, and August. Beginning at the city of New York this isotherm runs nearly due north to Albany, and then curves westward and slightly southwest, touching the edge of Lake Erie near Sandusky. It runs thence in a northwesterly direction to Lansing, Michigan, and thence southwest to Michigan City, Indiana. Thence it continues in a northwest direction through Madison, Wisconsin, to a point a few miles south of Eau Claire, whence it continues almost due west to South Dakota. Entering Dakota the line makes a sharp curve to the north, and near the one hundred and first meridian turns almost due south until it reaches the 33° of latitude in New Mexico, near the Mexican border. Its further tracing across the Rocky Mountains is not necessary here. Extending for 100 miles on either side of this line the map shows a belt extending from the Atlantic to the Pacific, within whose limits the most favorable conditions for growing beets, as far as temperature alone is concerned, will be found.

The mistake must not be made of supposing that all the region included within the boundaries of this zone is suitable for beet culture. Rivers, hills, and mountains occupy a large portion of it, and much of the rest would be excluded for various reasons. In the western portion perhaps all but a small part of it would be excluded by mountains and drought. Beginning at a point midway between the one hundredth and one hundred and first meridan, beets could be grown only in exceptional places without irrigation. On the Pacific coast only that portion of the zone lying near the ocean will be found suitable for beet culture.

On the other hand, there are many localities lying outside the indicated belt, both north and south, where doubtless the sugar beet will be found to thrive. The zone, therefore, must be taken to indicate only in a general way those localities at or near which we should expect success to attend the growth of sugar beets in the most favorable conditions other than temperature alone.

In respect of the rainfall it is necessary to call attention to the fact that a wet September and October are more likely to injure a crop of sugar beets than a moderately dry July or August. A wet autumn succeeding a dry summer is almost certain to materially in-

jure the saccharine qualities of the beet before it can be properly harvested. In this regard it will be seen from the tables of precipitation that the two Dakotas are more favorably situated than Oregon and Washington.

The rainfall in Oregon and Washington for September and October is 2.17, 3.25, and 2.24, and 4 inches, respectively, while in the two Dakotas it is only 1.11, 1.27, and 1.54 and 1.26 inches. The importance of this slight rainfall in securing a safe harvest without danger of second growth is easily recognized.

During the winter months the temperature that is best for beets is one of uniformity and sufficiently low to prevent sprouting or heating in the silo. Sudden and extreme variations are alike injurious—on the one hand causing danger from freezing and on the other from sprouting. On the coast of California the winters are so mild that the beets require very little protection, in fact more from the heat than the cold, while in Nebraska and the Dakotas the temperature often falls so low as to endanger the beets even in well-walled silos.

All these problems in meteorology deserve the most careful consideration from those proposing to engage in the sugar-beet industry, and it is hoped that the subjoined tables may help to elucidate them.

Table showing the average precipitation, for each month of the year, at the stations specified. (*Deduced from observations during the period January*, 1880, *to December*, 1889.)

State and station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Maine:	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
Cornish	4.24	4.47	3.24	2.65	3.36	2.94	4.54	3.19	3.76	3.88	4.43	3.93
Eastport	4.64	4.49	4.68	3.14	4.82	3.72	4.49	2.82	3.16	4.89	4.22	5.26
Gardiner	5.02	5.20	4.27	3.31	3.53	3.09	3.47	2.48	3.62	3.80	3.86	4.64
Orono	4.52	4.64	4.06	2.76	3.60	3.29	3.70	3.33	3.38	3.76	4.44	4.45
Portland	4.22	4.72	3.28	2.90	3.42	3.04	3.96	3.23	3.51	4.02	4.21	4.44
	4.53	4.70	3.90	3.15	3.75	3.22	4.03	3.01	3.49	3.87	4.23	4.54
New Hampshire:												
Antrim	*4.61	*4.27	*3.72	2.80	3.95	3.37	4.53	3.43	4.32	4.00	4.30	4.11
Concord	3.83	3.55	2.79	2.14	2.88	3.03	3.67	2.98	3.74	3.16	3.12	3.41
Hanover	†2.84	†2.55	†1.84	†1.30	†2.70	‡2.90	‡3.38	†2.87	†2.49	†2.48	†3.27	†2.47
Weir's Bridge	3.84	3.73	2.89	2.32	3.14	3.18	4.01	3.17	3.94	3.40	3.68	3.90
	3.78	3.52	2.81	2.14	3.17	3.12	3.90	3.11	3.62	3.26	3.59	3.47
Vermont:												
Burlington	1.68	1.48	1.78	1.67	2.86	2.98	2.82	3.08	3.64	3.12	2.88	1.85
Lunenburgh	2.99	2.49	2.33	1.15	3.14	3.35	3.60	3.25	3.41	3.76	3.10	2.82
Strafford	3.64	3.16	3.14	1.90	3.06	2.95	4.52	3.61	3.70	3.02	3.92	3.28
Woodstock	*3.00	*2.77	*2.68	§1.66	§3.16	§2.24	*3.98	*3.00	‖3.41	*2.68	*2.09	*3.27
	2.83	2.48	2.48	1.60	3.06	2.88	3.73	3.24	3.54	3.14	3.00	2.80
Massachusetts:												
Amherst	4.23	3.72	3.62	2.53	3.59	3.45	4.69	4.08	4.50	3.40	3.77	3.67
Boston	4.81	3.99	3.64	2.73	3.86	2.81	3.51	3.58	3.30	3.62	3.38	3.27
Fitchburg	4.61	3.56	2.66	2.56	3.14	2.79	4.05	3.85	3.74	3.24	3.31	3.31
Lawrence	*5.44	*4.28	*3.91	*2.75	§3.30	§2.84	§4.18	§4.87	§3.59	§3.77	§4.69	§3.58
New Bedford	4.78	4.76	3.99	3.45	3.61	3.07	4.00	4.08	3.45	3.56	3.97	3.92
Springfield	†4.44	†4.36	†3.23	†2.65	†3.48	†3.80	†4.97	†4.09	†3.52	†3.62	†3.72	†3.84
Williamstown	†3.34	†3.25	3.10	†2.60	3.02	2.98	†4.61	†3.72	3.05	2.62	3.24	†3.40
Worcester	‡4.56	‡4.42	‡3.49	‡2.67	†4.13	‡3.63	‡3.38	‡3.33	†3.84	†3.85	†3.96	†4.06
	4.53	4.04	3.46	2.74	3.52	3.17	4.17	3.95	3.62	3.46	3.76	3.69
Rhode Island:												
Narragansett Pier	*5.84	*4.95	*4.28	‡3.27	‡2.88	‡2.69	†3.89	‡3.99	‡3.40	‡4.46	‡4.32	‡3.78
Providence	†6.19	†6.30	†4.33	†3.22	†3.67	†2.99	‡4.07	†4.06	†3.29	†4.10	†4.11	†4.59
	6.02	5.62	4.30	3.24	3.28	2.84	3.98	4.02	3.34	4.28	4.22	4.18

* For seven years. † For nine years. ‡ For eight years. § For six years. ‖ For five years.

Table showing the average precipitation, for each month of the year, at the stations specified, etc.—Continued.

State and station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Connecticut:	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
Hartford	5.10	4.39	3.49	2.53	3.37	2.61	5.02	4.01	3.49	3.97	3.88	4.19
Middletown	3.52	4.95	4.27	2.70	3.17	3.30	5.02	3.59	4.17	4.25	4.02	4.38
New Haven	4.44	4.56	4.30	2.64	3.84	3.14	5.37	4.67	4.04	3.97	3.48	3.97
New London	5.25	5.41	4.46	3.36	3.94	3.47	4.04	4.55	3.77	4.72	4.40	3.77
	4.58	4.83	4.13	2.41	3.58	3.13	4.86	4.20	3.87	4.23	3.94	4.08
Northern New York:												
Albany	2.95	2.56	2.72	2.24	3.13	3.58	3.08	3.67	3.28	3.18	3.46	2.94
Oswego	3.18	2.93	2.49	1.99	3.02	3.61	2.60	2.41	2.66	2.92	3.47	3.66
Rochester	2.61	2.35	2.35	2.16	3.61	3.37	2.30	3.10	2.10	2.63	2.58	2.44
	2.91	2.61	2.52	2.13	3.25	3.52	2.86	3.06	2.68	2.91	3.15	3.01
Northwestern Pennsylvania:												
Erie	3.38	3.79	2.58	2.76	3.46	4.29	2.73	3.29	3.71	4.06	4.46	3.47
Franklin	3.90	3.38	2.52	2.41	3.50	6.12	4.04	3.54	3.27	2.89	2.94	3.25
	3.64	3.58	2.55	2.58	3.48	5.20	3.38	3.42	3.49	2.48	3.70	3.36
Northern Ohio:												
Cleveland	2.44	3.37	2.34	2.20	2.52	4.03	3.47	2.58	3.38	2.56	3.07	2.54
Sandusky	2.14	3.18	2.38	2.34	3.64	4.29	3.08	3.37	2.59	2.51	2.72	2.54
Toledo	2.14	2.55	1.95	1.98	3.78	3.67	3.29	2.44	2.54	2.92	2.74	2.30
Wauseon	2.40	3.17	2.47	2.43	4.58	3.90	3.51	2.65	2.12	3.14	3.26	2.55
	2.28	3.07	2.28	2.24	3.63	3.97	3.34	2.75	2.66	2.78	2.95	2.48
Northern Indiana:												
Logansport	2.14	4.24	2.59	3.04	5.29	5.15	3.71	2.76	3.08	3.03	3.55	3.44
Michigan:												
Adrian	2.25	*3.48	*2.47	2.60	4.44	4.90	3.81	3.24	3.38	3.79	3.44	2.70
Alpena	3.08	2.61	2.27	2.23	3.81	4.21	3.07	3.24	3.57	3.71	3.16	2.90
Escanaba	2.04	1.68	1.59	2.06	3.17	3.84	2.74	3.64	4.16	3.51	2.26	2.44
Grand Haven	2.78	3.21	2.38	2.45	3.21	4.04	3.57	3.23	3.50	3.75	2.75	3.14
Kalamazoo	2.46	2.96	1.87	2.24	4.36	4.96	2.93	2.52	3.06	2.84	2.39	2.93
Lansing	1.96	2.68	2.55	2.24	3.92	4.43	3.17	2.90	3.14	3.21	2.66	1.80
Marquette	3.28	*1.88	1.74	2.68	2.71	3.24	2.74	3.27	4.27	3.06	2.72	2.96
Port Huron	2.34	2.97	2.40	2.00	3.43	3.60	2.62	2.44	2.16	2.76	2.63	2.26
	2.52	2.68	2.16	2.31	3.63	4.15	3.08	3.06	3.40	3.33	2.75	2.64
Northern Illinois:												
Chicago	2.22	3.03	2.19	3.08	3.83	3.53	3.86	3.42	2.88	3.65	2.82	2.42
Riley	2.28	2.66	2.37	2.61	3.25	3.64	3.18	3.44	3.16	3.14	2.00	2.05
Sycamore	†2.12	†2.40	†2.10	†3.70	*4.06	*4.78	*4.68	*3.47	*3.23	*4.21	*2.56	*2.59
	2.21	2.70	2.22	3.13	3.71	3.98	3.91	3.44	3.09	3.67	2.46	2.35
Iowa:												
Cresco	1.47	1.11	1.64	2.27	3.73	*4.53	*5.19	*3.52	*4.26	2.29	1.28	1.50
Davenport	1.55	1.91	2.14	2.38	4.42	4.47	3.85	3.64	3.41	3.75	1.88	1.92
Des Moines	1.31	1.29	1.40	2.94	5.30	5.88	4.02	3.74	3.95	3.66	1.77	1.54
Dubuque	1.83	1.84	2.23	2.73	4.12	4.74	4.66	3.39	4.47	3.22	1.75	2.11
Logan	†1.86	1.26	1.42	3.05	4.49	5.82	5.22	3.93	3.00	2.94	*1.44	†1.32
	1.60	1.48	1.77	2.67	4.41	5.09	4.59	3.64	3.82	3.17	1.62	1.68
Wisconsin:												
Embarrass	2.96	2.65	2.27	2.92	4.45	5.71	5.15	5.58	5.05	4.17	2.94	3.14
La Crosse	1.31	0.99	1.45	2.10	2.80	3.57	5.00	3.85	4.71	2.15	1.32	1.32
Madison	2.08	2.30	2.54	2.92	3.56	4.64	5.36	3.76	3.71	3.28	1.76	2.55
Milwaukee	1.96	2.36	2.16	2.18	2.78	3.95	3.80	2.68	2.71	2.24	1.60	2.22
	2.08	2.08	2.10	2.53	3.40	4.47	4.83	3.97	4.04	2.98	1.90	2.31
Minnesota:												
Duluth	1.26	.34	1.35	2.44	3.50	4.52	3.32	4.14	3.90	3.14	1.76	1.33
Moorhead	*0.82	*0.86	*0.76	*2.18	*2.75	*3.84	*4.37	*2.70	*2.40	*2.25	*0.93	*0.83
St. Paul	1.21	1.00	1.21	2.69	2.58	3.55	3.53	2.99	3.24	1.64	1.22	1.33
	1.10	1.07	1.11	2.44	2.98	3.97	3.74	3.28	3.18	2.31	1.30	1.16
North Dakota:												
Bismarck	0.52	0.61	0.67	1.86	2.11	2.98	2.68	1.98	0.88	1.04	0.52	0.75
Fort Buford	0.66	0.43	0.42	1.11	1.51	3.07	1.96	1.55	0.84	0.80	0.35	0.56
Fort Totten	0.48	0.59	0.38	1.21	2.11	3.84	2.62	2.66	0.80	1.49	1.02	0.75
St. Vincent, Minn	*0.48	*0.50	*0.53	*1.26	*2.00	*3.01	*2.70	*2.28	1.93	1.76	0.56	0.71
	0.54	0.53	0.50	1.37	1.93	3.22	2.49	2.12	1.11	1.27	0.61	0.69

* For nine years. †For eight years. * For six years.

Table showing the average precipitation, for each month of the year, at the stations specified, etc.—Continued.

State and station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
South Dakota:	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
Deadwood, Rapid City	1.25	1.34	1.78	3.98	4.19	3.66	2.70	2.31	0.86	1.06	1.24	1.12
Fort Sisseton, Wadsworth	0.39	*0.37	*0.87	*1.78	*2.33	*3.50	*3.16	*3.38	*1.30	*1.81	†0.56	*0.52
Fort Sully	0.51	0.43	0.53	1.84	2.10	3.16	2.67	2.23	0.82	0.52	0.36	0.49
Yankton	0.59	0.77	1.05	3.35	4.83	3.14	3.16	3.30	3.17	1.66	0.84	0.87
	0.68	0.73	1.06	2.74	3.36	3.36	2.92	2.80	1.54	1.26	0.75	0.75
Nebraska:												
De Sota	1.00	0.86	1.55	2.29	3.64	4.71	3.86	3.55	2.56	2.45	0.89	1.10
Genoa	0.93	0.67	1.03	2.85	3.96	4.21	4.57	2.86	3.29	1.68	0.66	0.86
North Platte	0.34	0.38	0.70	2.03	3.30	3.58	2.76	2.72	1.57	1.37	0.37	0.55
Omaha	0.82	0.91	1.33	2.93	4.64	5.76	5.26	3.55	3.06	2.97	0.92	0.94
	0.77	0.70	1.15	2.52	3.88	4.56	4.11	3.17	2.62	2.12	0.71	0.86
California:												
Benicia Barracks	2.87	*2.06	*2.75	2.62	0.70	0.30	Trace	Trace	0.25	†1.33	*2.10	4.60
Fort Bidwell	3.51	2.46	2.03	*2.31	†1.11	†1.13	*0.32	*0.09	*0.27	*1.66	1.90	*3.47
Fort Gaston	9.99	6.45	4.30	5.69	2.60	0.96	0.10	*0.04	*0.88	*3.55	4.76	10.68
Los Angeles	2.39	3.38	3.35	1.92	0.41	0.16	0.04	0.06	0.07	1.07	1.67	4.29
Red Bluff	3.05	2.04	2.80	2.54	1.00	0.65	0.01	0.00	0.63	1.83	3.33	5.44
Sacramento	3.15	2.28	3.17	3.01	0.77	0.25	0.00	0.00	0.03	1.29	2.52	4.96
San Diego	1.91	2.38	2.05	1.19	0.50	0.09	0.01	0.05	0.02	0.63	0.76	2.40
	3.82	3.01	2.92	2.75	1.01	0.51	0.07	0.03	0.31	1.62	2.43	5.12
Oregon:												
Albany	7.92	5.70	3.67	3.51	2.27	1.71	0.60	0.40	1.78	3.76	3.98	8.76
Eola	7.16	4.73	3.27	2.73	1.84	1.39	5.48	5.22	1.84	3.40	3.59	7.06
Fort Klamath	3.62	2.44	*1.42	1.52	1.35	‡1.49	5.70	1.14	4.73	†1.68	*1.99	*4.19
Portland	7.28	4.97	3.72	3.66	2.48	1.71	0.61	0.56	1.93	4.31	5.01	9.56
Roseburgh	6.06	3.92	2.30	2.87	1.55	1.48	0.51	0.15	*0.58	3.01	3.18	6.78
	6.41	4.35	2.88	2.86	1.90	1.56	2.58	1.49	2.17	3.25	3.55	7.27
Washington:												
Blakeley	6.25	4.32	4.02	2.81	2.05	1.48	0.83	0.80	2.15	3.73	4.22	7.86
Fort Canby	8.08	7.15	5.94	4.63	3.06	2.37	1.26	0.87	3.35	6.26	6.96	9.84
Olympia	8.68	5.78	4.14	3.83	2.50	1.70	0.71	0.56	2.54	4.31	4.97	9.09
Port Townsend	2.71	1.46	1.33	1.73	1.43	1.28	0.98	0.74	0.90	2.54	2.17	3.08
	6.43	4.68	3.86	3.25	2.26	1.71	0.94	0.74	2.24	4.06	4.58	7.47

* For nine years. † For eight years. ‡ For seven years.

Table showing the mean temperature in degrees Fahr. for each month of the year at the stations specified. (*Deduced from observations during the period, January,* 1880, *to December*, 1889, *inclusive.*)

State and station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Maine:	°	°	°	°	°	°	°	°	°	°	°	°
Cornish	18.1	20.4	27.6	41.4	55.3	65.3	68.6	66.5	58.5	45.7	34.7	24.4
Eastport	20.4	21.9	28.1	38.4	47.3	55.8	60.5	60.4	55.8	46.3	37.4	26.5
Gardiner	17.9	20.6	26.7	41.0	53.5	*62.0	67.2	65.0	58.3	46.5	36.8	25.6
Orono	15.4	18.8	27.0	40.0	52.0	62.5	67.0	65.0	57.3	45.1	35.2	23.6
Portland	23.0	25.1	32.0	44.8	54.3	63.9	68.4	72.7	59.9	48.8	39.4	29.2
	19.0	21.4	28.3	41.1	52.5	61.9	66.3	65.9	58.0	46.5	36.7	25.9
New Hampshire:												
Concord	21.5	24.5	30.8	45.3	57.2	65.3	69.4	67.1	60.3	49.0	38.7	28.2
Hanover	*17.5	18.8	26.6	40.6	56.5	64.1	69.3	65.6	58.2	45.6	33.8	22.4
	19.5	21.6	28.7	43.0	56.8	64.7	69.4	66.4	59.2	47.3	36.2	25.3
Vermont:												
Burlington	18.7	20.6	27.5	42.8	58.6	66.6	71.0	69.2	61.6	47.6	37.1	25.6
Lunenburgh	14.5	16.8	24.0	38.8	55.4	63.3	67.3	65.1	57.9	44.2	33.2	21.5
Strafford	15.1	17.6	25.1	41.3	57.1	63.9	69.5	67.5	59.3	46.3	34.8	22.4
Woodstock	12.8	18.1	25.3	40.4	55.7	64.7	68.8	65.3	58.2	45.1	32.6	21.3
	15.3	18.3	25.5	40.8	56.7	64.6	69.2	66.8	59.2	45.8	34.4	22.7

* For nine years.

Table showing the mean temperature in degrees Fahr. for each month of the year at the stations specified, etc.—Continued.

State and station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Massachusetts:	°	°	°	°	°	°	°	°	°	°	°	°
Amherst	23.3	25.0	32.1	46.2	57.9	66.6	70.7	68.0	61.4	49.0	39.5	29.6
Boston	26.7	28.1	33.3	44.6	55.7	65.9	70.3	68.5	62.2	50.8	41.8	32.2
Fitchburg	21.9	23.6	29.0	42.8	56.4	65.8	69.7	66.8	60.2	47.3	37.1	27.6
Lawrence	*22.7	*22.7	*31.0	*45.2	*58.8	*67.2	*72.0	*67.2	*59.8	*48.0	†38.4	‡27.6
New Bedford	27.5	28.4	33.1	43.9	54.1	64.1	69.2	67.3	60.1	51.0	42.6	31.8
Springfield	24.0	25.9	32.5	46.8	60.5	68.8	72.8	68.9	63.3	50.4	40.0	§30.0
Williamstown	20.2	22.6	28.2	42.7	56.8	64.6	68.2	64.6	58.7	47.0	37.1	26.6
Worcester	23.4	23.9	30.0	‖42.8	‖55.2	§65.1	§70.0	66.8	§60.7	§48.0	38.7	28.6
	23.7	25.0	31.2	44.4	57.0	66.0	70.4	67.3	60.8	48.9	39.4	29.2
Rhode Island:												
Providence	*25.3	*28.5	*32.2	*45.4	*56.5	*67.6	‡73.1	*69.8	*62.1	*51.2	*41.9	*31.1
Connecticut:												
Hartford	‡22.4	‡24.0	‡30.3	‡46.7	‡59.4	‡67.2	‡72.2	‡68.2	†60.7	*48.6	*39.8	*29.2
Middletown	†24.3	†23.9	†31.4	†46.4	†58.7	†65.9	†70.5	†67.2	‡55.5	†48.4	‡40.4	‡31.0
New Haven	26.5	28.1	33.5	45.7	57.3	66.3	71.0	69.0	63.3	51.7	41.6	32.0
New London	28.9	30.0	35.0	46.0	56.6	65.6	70.5	69.1	63.7	53.0	43.4	34.0
	25.5	26.5	32.6	46.2	58.0	66.2	71.0	68.4	60.8	50.4	41.3	31.6
Northern New York:												
Albany	23.4	25.6	32.1	47.1	60.7	69.0	73.1	70.7	63.8	51.1	40.7	30.0
Oswego	23.3	24.3	28.8	41.5	54.5	62.6	68.4	67.1	61.3	49.0	39.1	29.4
Rochester	23.1	24.0	28.8	42.7	56.6	§62.5	§69.5	§67.4	§62.2	48.7	38.2	29.1
	23.3	24.6	29.9	43.8	57.3	64.7	70.3	68.4	62.4	49.6	39.3	29.5
Northwestern Pennsylvania:												
Erie	26.1	27.2	31.3	43.8	57.2	65.8	70.6	68.7	63.2	51.8	40.9	32.5
Franklin	21.8	23.9	29.1	43.7	56.0	60.2	65.5	62.5	56.8	45.3	34.2	26.2
	24.0	25.5	30.2	43.8	56.6	63.0	68.0	65.6	60.0	48.6	37.6	29.4
Northern Ohio:												
Cleveland	25.3	27.8	32.5	45.1	58.8	66.7	71.1	69.0	63.8	52.1	40.1	31.4
Sandusky	25.8	28.4	33.6	45.4	§59.5	§67.0	§72.9	70.7	64.9	52.5	40.5	31.8
Toledo	25.2	27.9	34.2	46.8	59.8	68.5	73.2	70.2	64.1	52.1	40.3	31.3
Wauseon	24.4	24.9	31.8	46.0	58.5	67.2	71.9	68.9	62.9	49.8	36.9	27.7
	24.4	27.2	33.0	45.6	59.2	67.4	72.3	69.7	63.9	51.6	39.4	30.6
Northern Indiana:												
Logansport	§24.0	‖29.9	‖36.7	§52.9	§64.7	§71.2	§76.2	§73.9	‖67.2	*55.3	§40.0	§30.7
Michigan:												
Adrian	20.3	§25.9	§31.0	45.2	58.4	67.2	71.6	68.4	61.7	49.1	36.6	28.2
Alpena	16.9	16.7	22.9	36.4	49.0	49.0	64.7	63.0	56.7	44.7	33.2	25.0
Escanaba	13.6	20.2	21.2	32.6	45.1	54.4	59.5	57.1	51.2	40.4	28.2	20.1
Grand Haven	23.3	24.2	30.0	43.4	54.7	63.2	68.2	66.3	59.2	49.2	38.0	30.0
Kalamazoo	20.6	23.7	30.3	46.2	57.6	67.1	72.3	69.1	62.4	50.4	36.5	28.1
Lansing	21.1	23.4	30.5	45.8	58.6	68.3	72.7	69.8	62.7	44.8	32.9	22.8
Marquette	14.5	§15.5	21.8	36.6	49.1	57.6	64.2	62.3	56.1	44.5	31.9	23.8
Port Huron	19.2	21.7	28.1	41.5	53.1	63.3	68.3	67.0	60.6	48.8	35.7	26.9
	18.7	21.7	27.0	41.0	52.4	62.5	67.7	65.4	58.8	46.5	34.2	25.6
Northern Illinois:												
Chicago	22.4	26.3	34.1	46.0	56.4	65.4	71.4	70.6	64.2	52.5	39.2	30.2
Rileyville	14.6	19.5	29.1	45.6	56.1	65.7	70.3	67.9	60.2	47.9	33.3	23.1
Sycamore	‖15.3	‖21.0	‡30.4	*46.0	§54.5	§66.8	§71.2	§68.6	§59.9	§48.7	§35.5	§26.2
	17.4	22.3	31.2	45.9	55.7	66.0	71.0	69.0	61.4	49.7	36.0	26.5
Iowa:												
Cresco	7.4	13.6	26.7	44.4	56.2	§66.2	§70.4	§68.1	§58.6	45.8	29.0	18.3
Davenport	19.4	24.9	35.0	50.1	61.2	69.7	74.8	72.2	64.4	52.2	38.2	28.3
Des Moines	16.6	23.1	34.7	50.2	60.9	69.8	74.5	72.1	63.5	51.7	36.6	26.5
Dubuque	16.1	21.7	32.7	48.6	60.1	68.5	73.6	70.9	63.6	50.4	35.7	25.6
Logan	16.5	22.4	35.2	51.7	63.2	71.6	75.9	74.0	65.9	52.4	36.1	26.1
	15.2	21.1	32.9	49.0	60.3	69.2	74.6	71.5	63.2	50.5	35.1	25.0
Wisconsin:												
Embarrass	11.2	15.5	26.4	44.2	59.1	68.0	71.0	68.2	60.9	48.5	32.4	21.2
La Crosse	13.4	19.1	30.5	47.3	59.8	68.5	72.7	69.8	61.4	49.5	34.3	23.8
Milwaukee	17.9	21.9	30.3	42.4	53.3	61.7	68.4	67.4	60.7	49.7	36.0	26.4
	14.2	18.8	29.1	44.6	57.4	66.1	70.7	68.5	61.0	49.2	34.2	23.8

*For seven years. †For five years. ‡For six years. §For nine years. ‖For eight years.

Table showing the mean temperature in degrees Fahr. for each month of the year at the stations specified, etc.— Continued.

State and station.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Minnesota:	°	°	°	°	°	°	°	°	°	°	°	°
Duluth	7.9	12.4	23.2	37.5	48.1	57.3	65.2	63.6	55.2	44.4	29.5	17.8
Moorhead	2.9	2.9	20.0	40.2	53.6	64.5	67.6	65.1	55.3	39.0	21.9	11.1
St. Paul	9.1	14.9	27.9	45.3	57.8	66.9	71.3	68.6	60.0	47.2	31.0	19.4
	4.7	10.1	23.7	41.0	53.2	62.9	68.0	65.8	56.8	43.5	28.5	16.1
North Dakota:												
Bismarck	3.2	9.2	23.0	41.4	54.9	65.0	69.1	67.0	56.3	43.7	26.6	13.8
Fort Buford	2.6	9.3	24.0	41.7	53.9	64.2	68.0	66.1	54.8	42.6	25.8	10.8
St. Vincent, Minn	*7.5	*0.6	*15.3	*36.6	*51.7	*62.3	*65.0	*62.5	52.6	40.0	21.2	6.2
Fort Totten	*4.5	3.8	17.1	37.7	53.8	64.0	67.3	65.7	55.0	41.3	22.5	8.2
	1.6	5.7	19.8	39 4	53.8	63.9	67.4	65.3	54.7	41.9	24.0	9.8
South Dakota:												
Fort Sisseton	0.4	6.0	21.0	*40.9	*55.2	*65.0	*69.0	*65.1	*56.8	*43.0	*25.4	*11.2
Fort Sully	8.8	15.5	29.6	47.5	58.9	68.9	73.9	72.1	61.9	48.2	30.7	19.1
Deadwood	19.4	22.9	31.3	41.3	50.4	61.1	66.0	65.4	55.2	44.5	32.4	26.0
Yankton	12.6	18.2	30.6	47.0	59.3	69.2	73.5	71.3	61.8	49.6	33.0	22.4
	10.3	15.6	28.1	44.2	56.0	66.0	70.6	68.5	58.9	46.8	30.4	19.7
Nebraska:												
De Soto	14.5	21.5	34.0	50.7	61.5	70.5	74.9	72.6	63.5	51.1	34.4	24.4
Geneva	13.5	20.4	32.3	48.6	60.4	70.0	74.6	72.3	62.8	49.8	33.0	23.4
North Platte	18.6	25.1	35.1	48.5	58.1	68.3	73.2	71.1	62.0	49.6	34.5	27.0
Omaha	16.6	23.4	35.1	51.1	62.2	71.4	76.2	74.4	64.3	52.0	37.0	26.7
	15.8	22.6	34.1	49.7	60.6	70.0	74.7	72.6	63.3	50.6	34.7	25.1
California:												
Benicia Barracks	46.6	*49.6	*54.2	56.9	61.4	65.6	65.8	68.4	*66.6	61.7	54.2	50.3
Fort Bidwell	31.4	33.8	41.4	47.9	*55.9	*63.5	71.0	70.7	62.6	51.2	40.4	35.8
Fort Gaston	41.0	43.7	49.8	†53.8	59.8	65.0	71.8	69.3	63.7	54.5	46.0	44.2
Los Angeles	53.6	54.4	56.2	59.0	62.2	65.9	69.4	70.6	68.7	63.1	58.7	55.5
Red Bluff	45.5	49.1	55.2	59.8	67.5	75.2	82.1	80.5	*74.7	62.7	*52.7	47.5
Sacramento	45.5	49.4	54.7	58.2	63.4	68.2	71.9	71.8	69.6	61.0	52.4	47.5
San Diego	53.5	54.7	56.1	58.8	61.5	64.4	67.2	69.1	67.2	62.6	53.3	56.3
	45.3	47.8	52.5	56.3	61.7	66.8	71.3	71.5	67.6	59.5	51.1	48.2
Oregon:												
Albany	38.6	40.9	47.5	51.8	57.9	61.0	66.3	65.4	62.1	*49.0	43.2	41.8
Eola	37.6	39.8	46.8	50.1	55.8	60.3	60.7	64.4	59.1	51.6	43.7	41.5
Fort Klamath	†26.4	†26.8	‡34.7	†40.0	†49.7	‡56.9	†61.6	†62.1	†51.7	§41.5	†33.2	†30.4
Portland	37.0	40.0	47.	51.8	58.0	62.1	66.4	65.3	60.6	53.0	44.8	41.6
Roseburgh	40.4	41.6	47.5	51.6	57.1	61.4	66.5	65.0	61.4	52.2	44.5	43.2
	36.0	37.8	44.8	49.1	55.7	60.3	64.3	64.4	59.0	49.5	41.9	39.7
Washington:												
Blakeley	38.5	40.3	46.1	50.8	56.0	61.2	63.3	62.7	57.6	51.0	45.1	41.8
Fort Canby	41.0	41.7	46.0	49.0	53.2	56 5	59.0	59.5	57.8	53.0	47.1	44.1
Olympia	37.6	39.0	44.5	48.7	54.5	59.2	62.3	61.9	56.2	50.1	43.8	40.6
Fort Townsend	*38.7	*39.3	†46.2	51.3	55.0	60.0	62.0	61.2	†56.4	*53.4	*44.0	*40.9
	39.0	40.1	45.7	50.0	54.7	59.2	61.6	61.3	57.0	51.9	45.0	41.8

* For nine years. † For eight years. ‡ For six years. § For seven years.

Dr. McMurtrie, in special report No. 28, has made a careful study of the climatic conditions in the United States favorable to the production of the sugar beet. Maps are given showing the southern limit of a mean temperature of 70° Fahr. for the three summer months, coupled with a minimum mean rainfall of 2 inches per month for the same period. The tables of temperature and rainfall from which these lines were computed are also given in detail. The observations made on the data collated are as follows:

"We see from this that the sections of the United States most favorable to beet-root culture are confined to the North, including New England, New York, a narrow band south of the lakes, Michi-

gan, parts of Wisconsin, Minnesota, and Dakota. Here the line of the southern limit passes into the British possessions and enters the United States again in Washington Territory, and crossing Western Oregon, passes to the coast to the extreme north of California. In most of this band we find a favorable temperature, and the average rainfall is sufficient in quantity, but we are unable to make any observations concerning the number of rainy days. In California, as the tables will show, the temperature is sufficiently moderate, but, from examination of the figures for the stations for which the rainfall has been recorded, we find it to be remarkably deficient. Here, in order to make the culture a success, it would appear that the intervention of irrigation during the summer months would be an absolute necessity.

"We also note a few counties in the southwestern portion of Pennsylvania, and one county in Ohio, without the general band, where suitable meteorological conditions seem to exist. These counties are surrounded by the red line in the more detailed map that has been prepared, showing the county lines near to or over which the line of the limit of favorable meteorological conditions passes. This map is intended for more ready reference for those who may contemplate establishing the culture in the sections in the near neighborhood of the line.

"Now, I do not mean to assert that the band of country I have thus plotted on the map is exclusively that in which the introduction of beet-root culture may be attempted with prospects of success, but it is certain that within this band the chances of success are greater than they are without it, and it also appears that all the unsuccessful attempts that have heretofore been made to establish the industry have been at points without it. It is therefore advisable that farmers or manufacturers who may design entering upon the prosecution of this industry should study with greatest care these influences which operate with so much benefit or injury upon the profit of the crop. It is evident from what precedes that the beet requires a cool or at least a moderate season for suitable progress in development, that it may not reach maturity in advance of the time for working it into sugar, and under the influence of the rains and elevated temperature of the autumn months enter into a second growth, thereby destroying the valuable constituents which render it so desirable as a sugar-producing crop.

"In this connection it has been suggested that in sections of protracted warm seasons, where the root will develop and attain full maturity in August and during the summer drought, the crop could be taken up before the appearance of the autumn rains, and by slicing and drying the roots preserve them until the arrival of the proper season. This mode of procedure has in fact been recommended to the agriculturists of the south of France, and has, it has been stated, been the subject of experiment in Algeria. The method has the objection of being a rather precarious one on account of the chances of the crop being caught after a long-continued drought by late heavy summer showers that would prove almost as injurious as the autumn rains.*

"After the directions given by Briem and others it is scarcely necessary to recapitulate here the meteorological conditions which appear

*The experiment of drying beets for preservation in Maine, in the fall of 1878, proved quite disastrous financially for those who engaged in the enterprise.

to be required by this culture, yet the conclusions arrived at from our study of the subject, in addition, may not appear superfluous. The conditions, then, are in general, comparatively dry and warm spring months during the time for preparation of the soil, planting, and cultivating the crop; moderate temperature, abundant and frequent rains during the summer months, the time for ultimate development of the crop and its valuable constituents; cool, dry fall, the time for ripening, harvesting, and storing the crop. If these conditions prevail, the results will be good; otherwise they will be but medium or even bad."

The amount of rainfall necessary to the proper growth of sugar beets depends largely on the character of the soil, the mean temperature, and the degree of saturation with aqueous vapor of the prevailing winds. In the coast valleys of California, where the proximity of the sea preserves a low temperature through the summer, and where the porous soil permits the tap root of the beet to descend after moisture and moisture to ascend to the root, excellent beets are grown with little rain. The conditions would be entirely reversed in inland localities with high summer heats, stiff clayey soils, and arid winds.

In general, the amount of rainfall during the summer months in the Northern, Central, and Eastern United States is sufficient to secure a good growth, and therefore it may be said that proper soil and attention being provided, beet culture might be undertaken in such localities with little fear of disaster from drought, save in a few exceptional seasons.

In fact, with thorough under drainage and deep subsoil plowing, it would be possible to secure a good crop of beets in the regions indicated quite independently of the variation in the amount of rainfall.

The chief question, therefore, to be considered, is one of temperature and sunshine rather than of rainfall. In the present state of our knowledge it would not be safe to establish beet factories very far south of the mean isotherm of 70° Fahr. for the three summer months, without a more thorough study of the character of the beets produced than has heretofore been made. The possibility of finding localities south of this line, where sugar beets may be grown with profit, is not denied, but the necessity of further investigation is urgent. There are many places situated only a short distance south of this line where the soil, water supply, cheap fuel, and other local considerations supply peculiarly favorable conditions for beet culture, and in such places the industry would doubtless flourish, although the beet might not be quite as rich in sugar as when grown in a more northern locality. In all cases the length of the growing season should be sufficient for the complete maturity of the beet, and the freezing temperatures of winter should come sufficiently late to allow the beets to be safely harvested and covered.

REPORT OF THE CHIEF OF THE DIVISION OF FORESTRY.

SIR: I have the honor to submit my fifth annual report upon the work of the Forestry Division.

With a new fiscal year increased appropriations have marked a new era for this Division, placing at its disposal for the first time funds sufficient to provide for following up in good earnest some special investigations. These funds became available, however, only a few months previous to the writing of this report, and since the arrangements for work were delayed for various reasons proposed methods and promises of results must as yet be discussed rather than the results themselves.

In the line of giving information in answer to requests by letter, the work of the Division has steadily grown. It is to be regretted that the information furnished on many topics is imperfect indeed, no means for acquiring it having hitherto been afforded, especially in the case of requests for statistics regarding timber supplies. The character of much of the correspondence of the Division is indicated by the following classified list of subjects of recent letters:

Statistics.—The loss of useful forest material by fire; present and future supply of white oak; lumber importations and duties; increase or decrease of forest area; soil, timber, and rivers of the Sioux Reservation; manufacture of short-leaved pine in Virginia and North Carolina; amount of long-leaved pine in Georgia and Florida; timber area in the United States and possibilities of exhaustion; area of standing hemlock in the United States and Canada; hard-wood products, markets, etc.; lumber industry of Florida; authors of works on forestry.

Technology.—Oaks suitable for cross ties and tan bark; method of preserving fence material; after treatment of wood when cut; effects of water seasoning upon holly; methods of preserving posts; quality of southern oak; comparative tests of northern and southern oaks; best material for railroad ballast and durability of various timbers in the roadbed.

Forest influences and forest policy.—Plan for seedling distribution; State purchase of land for forest purposes; State forestry legislation; advisability of a department for care of public grounds; repeal of timber-culture law; working of timber-culture law; precipitation before and after deforestation; maintenance of forest cover on mountain slopes; influence of forests and eucalyptus on malaria; protection of timber from fire by law; exemption of forest lands from taxation; artificial rainfall.

Forest planting.—(By regions.) Trees most likely to succeed in Texas; tree planting in Dakota; trees suitable for forest growth in Louisiana; experimental and mixed planting in Michigan; forest growth advisable for Colorado; forest trees for Dakota; growing forest trees from seed in arid regions; advisable mixture of trees for Texas; trees adapted to Arizona; trees suitable for the arid regions; trees for roadside planting; trees for grove planting in California; trees advised for Illinois; trees for street planting; suggestions on deciduous tree growth without irrigation; timber trees desirable for Minnesota; sea-coast planting; instructions for interplanting coniferous seedlings in Minnesota; pecan planting in Georgia; black walnut forest culture; English walnut and pecan culture in New Jersey; treatment of acacia seed in Arizona; treatment of juniper seed in Kansas; trees for shade and ornament in Florida; treatment in pole planting; availability of the ailanthus for Kansas; forest planting in Oregon; conifer seeding in Michigan; timber culture

without irrigation in Arapahoe County, Colorado; bamboo planting in Texas and California; climatic conditions for eucalyptus and cottonwood in Central Arizona; black walnut cultivation in Oregon; suitable forest trees for Arizona; reclamation of sand dunes. (By species.) Pinus cembra, its introduction in Maine; osier cultivation; suggestions on growing black walnut; directions for growing seedling conifers; growing cottonwood from seed; maple raising; black walnut planting; black walnut timber, range and cultivation; osier culture in New York and Michigan; acacia seed, its distribution, and value of acacia for tan bark; profitableness of wattles in California; germinating power of catalpa seed in Texas; bamboos, method of propagation; favorable sites for black walnut growing.

Forest management.—Treatment of naturally grown thicket of hard woods; best "works" on trees, their cultivation, etc.; pruning of trees; sumac as material for forest undergrowth; subsoil irrigation; time of transplanting; protection of trees against rabbits; advice on thinning white pine.

Forest botany, etc.—Proper time for gathering and planting seeds of white pine; sprouting of pitch pine; sprouts from conifer stumps; ring growth of trees; quality of wood in different parts of tree; long-leaved pine distinguished from other varieties; discoloration of timber due to fungus growth; locust trees, advice for preventing growth of; varieties of white cedar; hickories indigenous to the United States.

As I have pointed out repeatedly, the character of information expected from this Division is of a twofold nature, namely: technical, in so far as relates to forest management and the production of wood material, and statistical, in so far as the knowledge of the condition of our forest resources may induce application of forestry principles.

Information of the latter kind is needed to influence private activity in the rational utilization of forest supplies, in recuperation of natural forest areas, and in the planting of waste land; more especially, however, to justify the interest and the action of the Government in forestry.

There are three reasons implied why the Government has been induced to establish this Division, and to appropriate funds for forestry work. The first is that, owing to the heavy drains to which our virgin forest supplies are subjected without any provision for recuperation or reforestation, the future of wood supplies may be endangered. The second is that the methods at present followed in utilizing the natural forest areas are destructive, not only of the future forest resources, but also of the cultural and water conditions of the denuded and adjacent territory. A third reason is the desirability from economic considerations (for climatic ameliorations) of encouraging tree growth on the large treeless areas of the United States in the West and on the many places in the East and South which have been made so by irrational treatment on the part of man.

While in regard to the soundness of the third reason there can hardly be any doubt, there has never been a thorough investigation as to the validity of the former two, the work for the Tenth Census being the nearest approach to it.

To establish beyond controversy the fact that our timber supplies as at present utilized are being consumed at a rate more rapid than they are growing would, if at all possible, require a close examination of forest areas, standing merchantable timber, methods of lumbering, the annual drain by cutting, fire, pasturage, and decay, and also capacity for annual reproduction, that we might compare outgo and income.

The hopelessness of accomplishing such a task, especially with the slender means and inadequate organization of this Division, and the doubt whether the expenditure of money and energy in that direction would be fully justified by results, have deterred the Division from entering that field of statistical inquiry. Two years ago it was

proposed to settle the controversy as to available supplies of white pine at least. To accomplish this satisfactorily I estimated that not less than $15,000 would be required. Since then, although nobody can predict the time when this staple will be practically exhausted, indications of its rapid decline have become so unmistakable that an attempt to prove the fact would be needless waste of energy. The time of actual exhaustion of any timber, or of supplies of any particular kind, can never be foretold, for the simple reason that changes in the use of material, substitutes, and various other causes introduce uncertain factors into the calculation.

Several years ago I submitted that, with a resource which, like our forest resource, is determinable by area only, and which can and should be kept in perpetuity by natural reproduction, the rational manner of estimating its condition with reference to the furnishing of supplies is to compare our annual requirements with the possible annual reproduction upon the ascertained area. The area some time ago had been ascertained to be less than 500,000,000 acres of woodlands, capable of yielding at best at the rate of 25 cubic feet of wood per year per acre, or one-half only of what is estimated to be the present consumption annually. In addition to these estimates, which are believed to present the case as nearly correctly as can be done with our knowledge, we have reports from various manufacturers noting the decline of supplies of particular kinds, so that we may conclude that Government interest on the ground of the first reason cited is by no means premature.

It is to be regretted that the opportunity which the machinery provided by the Eleventh Census offered for ascertaining more definitely the present extent and condition of the resource has not been used to its full extent, and that we shall be compelled to remain in comparative ignorance and to reason on surmises or partial knowledge with regard to one of our most valuable controllable resources.

That it should not have been deemed desirable (or only partially so) in the present census to ascertain the condition of a resource which yields raw material of a value not less than one quarter of the value of all raw materials manufactured will be a surprise to those interested in the forests of the United States.

We should strive to know from decade to decade what changes in the forest areas and their conditions have taken place, just as we ascertain and compare the areas and crops of the agricultural resource. Such knowledge is called for more and more, for commercial purposes, as the area of virgin timber land available shrinks or falls into the few hands which control the lumber supply of the nation.

The call upon the Division to supply information as to where certain kinds of timber may be found in abundance, and as to location of large bodies of merchantable timber, can only be answered in a very general way, hardly satisfactory to the inquirer.

The second reason for Government interest in the forestry question, namely, the effect of unwise denudation upon soil, water flow, and climatic conditions, has been made a continued study by the Division; and while it has not been possible to institute direct experiments or systematic observations which would lead us to a plain demonstration of forest destruction and deterioration of soil or climate or water flow as cause and effect, the results of experiments and experiences in other countries have been published in former reports, and material is constantly gathered of similar experiences

in our own country. The question of forest influences on climate has been carefully studied by Prof. M. W. Harrington, of Ann Arbor, and the results of his investigations into the literature of the subject will be published as soon as opportunity is given.

I may state here that he has mainly occupied himself with a critical scrutiny of the systematic observations in forest meteorology carried on through many years in Europe. The results have been platted in graphic form for ready reference, and the publication will form a desirable basis for further inquiry or experiment, presenting a résumé of what has been definitely accomplished in solving the problem up to date.

My last report contained an analysis of the factors that need consideration in discussing the influence of forest on water supplies, a question which is growing in importance, especially in connection with the irrigation problems of the West.

Granting, then, the existence of sufficient reasons for the interest which the Government has so far taken in the forestry problem, the question every year presents itself anew as to how this interest should manifest itself; for, while it may be easy to recognize the disease, the remedies are not always found at once, and various trials must gradually lead to the selection of those most efficacious.

There are three methods open by which the Government can promote a change in present conditions: First, by placing its own timber holdings under rational treatment; secondly, by direct aid to those who would apply forestry principles in caring for the natural woodlands or in creating new forest areas; and thirdly, by the indirect aid imparted by supplying information.

The total absence of forest management on the timber lands belonging to the United States, nay, the almost total absence of any kind of reasonable management of the same while a forestry division exists in any Department of the Government, is such an incongruity that the influence of the latter must be considerably enfeebled by the reflection that the Government does not act upon its precepts.

The need of a change in this particular—the need of an effective forest administration for the remaining timber lands in the hands of the United States Government—has been pointed out every year in the reports of the Secretaries of the Interior, as well as in those from this Department.

It is the story of the Sibylline books repeated. Every year a part of the domain is wasted by fire, and while thus the value is depreciated without profit to any one, the chance of administering the remainder profitably is diminished. Five years ago I outlined the organization and probable cost of such an administration, and a bill was prepared and laid before Congress which, were it to become law, would enable the population of the Western States, where the Government domain is situated, to obtain their wood supplies in a legitimate manner, while now they are compelled to obtain them by illegal methods. Nor would the mountain sides, as at present, be denuded by fire and ax, not only rendering them waste places but endangering life and property below by giving rise to avalanches and soil-washing torrents, besides rendering the flow of water uncertain.

That the country at large, and especially the region in question, would be benefited by such a forest administration more directly than by any other means, this Division not excepted, must be clear to any unbiased student of the question.

The direct aid which the Government has held out in the interest of forest culture has consisted in permitting the acquisition of Government lands in the treeless regions free of expense, by planting one sixteenth of the areas to trees, and in charging this Division with the distribution of economic tree seeds and plants.

Both these methods, as practiced, have proved of little avail. As I have shown repeatedly in former reports, to make the distribution of plant material effective it would have to be done on a larger scale than the appropriations for the Division have ever warranted. Hence the distribution had to be confined to small trial packages, which may occasionally assist in spreading an interest in tree growth, but can hardly stimulate forest planting. Other difficulties in this method of Government aid have also been pointed out before. It has also been shown in my last and former reports that the timber-culture entries have in the majority of cases not produced the results for which they were intended. The reasons are various, but mainly, I believe, the frequent failures on the part of bona fide settlers to obtain the required stand of trees, necessitating their abandonment or changing the form of entry. These failures were due to unfavorable climatic conditions and to ignorance of methods and of plant material suited to the localities. This ignorance has been partially overcome by trial, with failure or success, and it may be questioned whether or not in future this method of Government aid could be made more effective by modifying the law, divesting it of its objectionable features, and providing for its proper execution. The repeal of the law failed to be accomplished during the last session of Congress, and I would submit that a revision at this stage of development might be preferable to a repeal.

The third method proposed, by which the Government could be effective in advancing forestry reform, is by disseminating information on the subject. This purpose is subserved by this Division. The kind of information needed, and the methods by which it may be obtained, I have outlined in my last and former reports. I may here only repeat that there is much desirable information which it is impracticable for the Division, as at present constituted and endowed, to obtain, such as the statistics of forest areas, etc., and again other classes of information which can be obtained only by experience, the results of experiment carried on through many years, which, therefore, though not now available, can be made so in time.

The method of imparting the information has been mainly by letter in answer to specific inquiry. The more general information, or such as may be considered complete within certain limits, is embodied in circulars or bulletins. In addition the chief of the Division has supplied addresses, papers, and informal talks to many associations and meetings during the year.

Two circulars, the one giving instructions for the growing of seedlings, and another for the treatment of seedlings in the nursery, were issued during the year. The most important publication during the year has been the final report of Mr. Tratman, promised in my last annual report as Bulletin 4, on the Substitution of Metal for Wood in Railroad Ties, prefaced with a brief discussion by myself on practicable economies in the use of wood for railway purposes. The practicability and ultimate economy, safety, and superiority of metal ties over wooden is proved by reports from all parts of the world, the reports giving the experiences with nearly 25,000 miles of

metal track in actual operation. The need of economy in this use of forest supplies will appear from the figures presented in the bulletin, which show that estimates based on actual returns from almost 60 per cent of the railroad mileage make the amount of wood used for the purpose of railroad building, in round figures, 500,000,000 cubic feet; over four fifths of which is consumed in railroad ties made from the thriftiest and most valuable timber, namely, oak, chestnut, and pine, with but a small percentage (16 per cent) of cedar, hemlock, cypress, redwood, and other woods. To supply this demand alone continually requires at least 10 per cent of our present forest area. That, even if the use of wood for this purpose be continued, certain economies are desirable and practicable, may also be learned from this report.

From year to year the publication of monographs on the life history of our important conifers has been promised, but always delayed for various reasons. It is hoped that their publication can be accomplished during the coming winter, the illustrations, want of which occasioned the last delay, having been completed. The publication is also expected, without much delay, of a check list of the arborescent flora of the United States. This will form the first of a series of forest botanical papers. The need of such a check list, especially one giving the common names, with their geographical distribution, appeared from the fact that nurserymen, lumbermen, lumber dealers, architects, and others using wood have often been misled by the indiscriminate use of the same names for widely different timbers. It is, for instance, a fact that the users of southern pine in the North are, as a rule, quite uncertain how to order and how to distinguish the three kinds that reach the market, since the same name is applied to each of the different kinds in various regions. Since, lately, the botanists have undertaken to revise the scientific nomenclature also, making the work of the last census, which was used as authority, as well as the botanical text-books, obsolete, it appeared desirable to make and publish the necessary revision in order to establish a basis for intelligent communication. With the aid of botanists throughout the country, who have kindly contributed their notes, it is hoped to unravel the confusion of common names, while the scientific names, that should henceforth stand as authoritative by the law of priority in naming, may be ascertained by reference to the literature of the subject.

This work of revision has proved more laborious and perplexing than was at first anticipated, since even prior revisers were found not to have been successful in all cases, and hence a careful study of authorities became necessary. This work has been diligently pursued by Mr. George B. Sudworth, the botanist of the Division, of whose zeal and efficiency I wish here to express my special recognition. Under his activity the forest botanical herbarium has grown to embody a desirable study material of several thousand specimens. The seed collection for the purpose of identifying the seed of different species now comprises 360 numbers, and a special study collection in alcohol of the buds of our forest trees (some 1,200 specimens of 100 species) has been made and studied with the view of arriving at characters for the ready recognition of our woody plants when without flowers or leaves.

The forest technological investigations referred to in former reports have, by the increase of appropriations, become possible on a scale which was hitherto unattainable. This work, which I desire

to discuss further on more in detail, as planned at present, may be considered the most valuable and promising in which the Division has been engaged since its creation, so far as technical scientific work is concerned. It consists mainly of a thorough examination of our prominent timbers in regard to their technical and physical properties in order to ascertain, if possible, how far these properties depend upon the conditions under which the trees are grown, how far physical properties influence mechanical properties, and also whether a simple method of determining by gross examination of structure the quality of timber can not be devised. The first work in this direction was undertaken to settle a controversy between carriage manufacturers as to the superior value of southern or northern grown oak. The results of the tests and investigations will appear further on. Many similar questions arise constantly, but we have so far only surmises, and no definite basis by which to settle them. The magnitude of the undertaking, the necessity of organized coöperation of various workers to supply each his part in the inquiry, makes this evidently an enterprise worthy of Government direction, and in fact is only practicable under such direction.

WOOD PULP INDUSTRY.

Various forestry interests have been canvassed by the agents who are assigned to this Division, as yet with incomplete results. The one to which I wish to direct special attention, as referring to the most important development in the use of forest products, relates to the manufacture of wood pulp.

It can be said, without fear of contradiction, that in no field of industrial activity has a more rapid development taken place within the last few years than in that of the use of wood for pulp manufacture. The importance of this comparatively new industry for the present, and still more for the future, can hardly be overestimated. Its expansion during the next few decades may bring revolutionary changes in our wood consumption, due to the new material, cellulose, fiber or wood pulp.

Though rapid in its growth, the industry has by no means reached its full development. Not only is there room for improvements in the processes at present employed, but there are all the time new applications found for the material. While it was in the first place designed to be used in the manufacture of paper only, by various methods of indurating it, its adaptation has become widespread; pails, water pipes, barrels, kitchen utensils, washtubs, bath tubs, washboards, doors, caskets, carriage bodies, floor coverings, furniture and building ornaments, and various other materials are made of it, and while the use of timber has been superseded in shipbuilding, the latest torpedo ram of the Austrian navy received a protective armor of cellulose, and our own new vessels are to be similarly provided. While this armor is to render the effect of shots less disastrous by stopping up leaks, on the other hand bullets for rifle use are made from paper pulp. Of food products, sugar (glucose) and alcohol can be derived from it, and materials resembling leather, cloth, and silk have been successfully manufactured from it. An entire hotel has been lately built in Hamburg, Germany, of material of which pulp forms the basis, and it also forms the basis of a superior lime mortar, fire and water proof, for covering and finishing walls.

According to the manner in which the raw material for the industry shall be secured it may prove either a new enemy to the forest or it may prove a saving element, rendering rational and profitable forest management in the United States possible and leading toward it. As I have shown elsewhere, such management in our natural woods depends largely upon the opportunity of marketing wood of small dimensions and inferior material, and this, by an economic development of the pulp manufacture, may be to some extent secured. Self-interest should lead the manufacturers to a study of the problem of forest management for continuous supplies, and mill men should combine with them to have the refuse, slabs, etc., worked up into useful material.

Ten years ago there were in Europe about five hundred wood-pulp establishments, making in round figures 15,000 tons of ground pulp, valued at over $5,000,000. With the development of the chemical processes since then it is hardly possible to tell from day to day how fast the production increases. To arrive at an idea how far this industry has developed in this country a canvass has been made among the pulp mills, the results of which have been tabulated below.*

In connection with this, considering the probable importance of the subject to forestry interests, it may be desirable to explain briefly the various processes, their advantages and disadvantages, their significance in connection with our forest resources, and to add suggestions which may be helpful in the development of the industry.

In the following brief statements I have followed, in part, the excellent résumé of the present state of the chemico-technical use of wood by the referee at the Vienna International Agricultural and Forestry Congress, where, if a more liberal policy had permitted a representation from this Department, probably much of additional value in this and other lines might have been learned. For the chemical reactions the recently published Dictionary of Applied Chemistry, by T. E. Thorpe (1890), has also been consulted.

It may first be stated that cellulose is the preponderating constituent of all vegetable tissues; in fact, elaboration of cellulose is synonymous with growth. In addition to the cellulose there are present in the wood nitrogenous substances, resins, gums, and (mineral) ash, which are to be removed, more or less, in order to produce the fiber or pulp. To do this economically and in such a manner that the fiber may remain long, pure, and white and the mass preserve its "felting" qualities as much as possible, is the aim of the various processes.

About half of the wood substance consists of cellulose, the soft woods containing, however, more than the hard woods; one reason why the former are preferred in the commercial production of pulp.†

* The first suggestion to use fiber for paper manufacture was made by a German, Jac. Christ. Schaeffer, in 1772; the first patent of commercial importance for chemical production was obtained by Watts & Burgess in 1853, and a small mill erected in London about 1855; the first large pulp mill was established in Manayunk, near Philadelphia, in 1865; in 1868 in England, in 1871 in Sweden, and soon afterward in Germany, where the modern processes have been mostly developed.

† The following percentages of cellulose in air-dried wood were determined by chemical analysis:

Poplar	62.8	Basswood	53
Fir	57	Chestnut	52.6
Willow	56.7	Locust	48.4
Birch	55.5	Beech	45.5
Pine	53.3	Oak	39.5 (**45.9**)

There may be now distinguished three classes of wood pulp, according to the manner of its manufacture, namely, mechanical, pseudo-chemical, and truly chemical pulp.

The preliminary preparation of the wood is the same for the different processes. It includes the cutting and splitting to suitable size for handling, the removing of the bark on the "barker" (a planing mill with two blades, or other contrivance); the removing of knots by the "knotter," an augur, and the removing of the pith by the pith cleaner, when necessary. For the chemical processes a further preparatory operation consists in the "chipping," which is done by knives placed on the face of cylinders, 5 feet in diameter, making 150 revolutions, having a bite of one eighth inch; the "chips" are further reduced mechanically by crushing rolls, after any knots and discolored pieces have been picked out from the moving apron which carries the chips from the chipper to the rolls.

(1) The *mechanical or ground pulp* is produced by grinding the wood, after proper preparation, on rapidly rotating stones under constant flow of water (Voelter process). For this process round wood is used of 4 to 8 inches diameter, cut into lengths of 10 to 20 inches, according to the face of the grindstones against which the wood is pressed lengthwise with the fiber.

Emery wheel cutters, using 40-horse power, will produce 50 pounds per hour of dry pulp, while natural stones, producing 25 per cent more pulp, require more than double the power. The ground mass, looking like thin gruel, is pumped into tanks, screened into vats, and then run off in thick sheets on the "wet machines" on which it is dried, folded, and pressed, containing still at this stage 60 per cent of water.

(2) *Brown wood pulp* is mainly a mechanical pulp, except that the wood is steamed before grinding, under a pressure of 2 to 6 atmospheres. This steaming, with a heat at 300° Fahr., produces a chemical reaction, the soluble nonvolatile ingredients of the wood forming powerfully acid bodies, which aid in the separation of the fiber; their corrosive action makes it necessary to use for the digesters vessels lined with copper or lead. After the wood is steamed, it is ground between millstones or in a rag engine (system Rasch & Kirchner). To avoid the acid reaction, and the necessity of noncorroding vessel linings, the addition of neutral sulphites has been proposed, when the organic acids combining with the base, are neutralized, a sulphite residue remaining. A sodium sulphite solution (5 per cent Na_2SO_3) with a high temperature, 356° Fahr., is used, the action of which, besides neutralizing the acids, seems mainly to consist in keeping the path open for continued action of the heat and water. It is claimed that this latter process has disadvantages in point of economy.

(3) *Chemical wood pulp*, or cellulose proper (in this country called chemical fiber), is produced by treating finely divided wood or wood shavings with various chemicals, which dissolve or render soluble the incrusting substances, leaving the fiber as long, elastic, and pure as the raw material will furnish it, while the above mechanical processes naturally shorten and deteriorate the fiber mechanically.

The chemical processes can be again classified into alkaline and acid processes, according to the kind of chemicals used. Of the many methods proposed only four or five have been developed with industrial success.

All these processes have in common the mechanical preparation of the wood, as described before, preceding the boiling with chemicals under pressure (which requires hermetically closed digesters, with anticorrosive linings) and subsequent washing out of the residual solution, screening, draining, and drying on "wet machines," and most of them, to produce the desirable white color, require a special bleaching process. The partial manufacture of the solvents and the recovery of the spent liquor of solution, or else its treatment for other useful materials, forms also part of the processes. Since the chemicals are apt to attack the fiber itself, a careful adjustment of their proportions is essential, otherwise the loss of

---

While these are laboratory results of European chemists, the following percentages, given by Charles M. Cresson, relate probably to pulping results:

Hemlock	45	Spruce	32
Walnut (very dry)	42	Cherry	32
Birch	40	Chestnut	30
Poplar (seasoned)	37	Hickory	22.6
Poplar (unseasoned)	30	Maple (unseasoned)	21.2
Yellow pine	36.5	Ash and oak (unseasoned)	20.6
White pine	33.25		

The general practice brings out still smaller results.

yield may increase unduly. The drying, after the processes of purification, is also an important part, since it is to be considered not a mere desiccation, but a chemical reaction, which, if not properly conducted, results in hardening and agglutination of the fiber.

Of alkaline processes there are two prominent:

(a) *Soda pulp* is produced when caustic soda lye under pressure and steam heat of 300° to 360° is used to remove the incrusting substances, carbonate of soda or solway salt and caustic lime being used to obtain the caustic soda, which can be easily and cheaply recovered by evaporation and calcination, the dissolved organic matter supplying the fuel for the latter part of the process of recovery. About 75 to 80 per cent is thus recovered as "black ash." The tank wastage, consisting of lime, silicates, and impurities, is apt to become a nuisance, if allowed to flow off into rivers, etc. The strength of solution, proportion of it to the material, temperature and duration of the digestion, vary considerably with different woods. The chemical changes are very complex and as the chemical action extends to the cellulose itself, the yield is thereby reduced.

(b) *Sulphate pulp* results from digesting the wood at a temperature of 300° to 360° in an alkaline mixture in which sulphates preponderate. This process, which is successfully worked in Europe, but seems unknown in this country, contains several points of economic importance. The liquor is made by treating sodium sulphate (glauber salts, 90 pounds of sulphate to 100 pounds of dry pulp) with caustic lime, when a certain proportion of the former is transformed into caustic soda. The liquor, after the boiling, is evaporated, calcined, and treated with lime, by which it is recovered as sulphide and hydrate (caustic soda) in nearly equal proportions, together with some sulphate; and with the addition of some sulphate (about 20 per cent) to compensate for the unavoidable loss, the cycle of operation is kept up.

The pulp from this process is of very high quality, similar if not superior to soda pulp, the only objection being that in consequence of the presence of some organic sulphur compounds it is somewhat malodorous, which, however, it might be possible to overcome. With cheap materials to begin with and easy recovery of the liquor, this should prove a very economic process. It is really almost the same as the one described as soda pulp, only that instead of buying the more expensive caustic soda, this is obtained in the process itself from cheaper and more easily transported materials. A recent patent by G. Hesse proposes boiling the wood with bisulphate of soda, then grinding the wood and using the spent liquor for the manufacture of sugar and alcohol.

The acid processes are more numerous and have come lately more to the front. Passing by the Bachet-Machard process, which, using dilute hydrocholoric acid, was employed in Switzerland for making coarse packing paper, and the Tilghman-Pictet process, employing sulphurous acid in lead-lined vessels, we come to the so-called (c) *sulphite pulp*, which is obtained when removing the incrusting substances by boiling the wood with acid sulphurous salts like the acid sulphite of lime ($Ca(HSO_3)_2$), or bisulphite of lime and magnesia $\binom{ca}{mg}(HSO_3)_4$). The various processes of this class (developed by Tilghman, Mitscherlich, Ekman, Francke, Graham, Macdougall, Flodquist, Kellner, and others) are identical in principle and differ only in technical detail. The boiling liquors vary in regard to acid strength (3 to 5 per cent) and proportion of base, temperature, and duration of digestion (300° to 350° and thirty to eight hours). Various woods require, of course, variation in strength of liquor, etc. All require special apparatus protected against the corrosive action of acids by a lead or other (special brick) lining. There are also digesters in use made of a bronze metal which resists the corrosion.

Under a recent patent (F. Salomon) a serviceable lining is obtained by heating the vessel filled with sulphite liquor or gypsum solution, which, when boiling, will deposit a durable crust. This crust, which forms itself during the process anyhow, used to be considered a nuisance, as it resisted removal, until it was discovered that its presence answered as a protective lining. It is claimed to be safer than the combined brick and lead lining for the reason that the latter is hidden from possible inspection, and any leaks occurring unforeseen give rise to explosions. The same patentee proposes several other methods of lining.

The source of the acid liquor is either sulphur or pyrites, burnt in suitable ovens, the fumes being led into towers ("acid towers"), where a constant, well-distributed supply of water flows over and through columns of basic material (calcined magnesia or lime) or a milky mixture of the latter agitated in special apparatus, the reaction in both cases resulting in bisulphite of lime, which collects at the bottom of the tower; from here it is led to the digesters (1,400 to 1,800 cubic feet capacity), in which the wood chips have been steamed before for five or six hours to soften them. The digesters, either stationary or rotary, are now filled up, nearly, with the bisulphite and the temperature raised to 225° and after a certain stage to 265°, at

which it is kept until near the close of the process, when it drops again to 220°, the boiling lasting for thirty to fifty hours. The liquor is then drawn off, the acid washed out of the pulp in vats under constant agitation, sifted, drained, and dried.

While the lime needed in the process is found almost anywhere—magnesite, which is found in California, and the dolomites, which are found more generally, and react more readily—the sulphurous constituents are not as easily obtainable. The supply of sulphur for the United States comes mainly from Sicily, although sulphur mines are opened in Utah near Salt Lake and in Humboldt County, Nevada (Rabbit Hole Mountain). Pyrite ores, which form the principal native source of sulphurous acid, are mined at Capleton, Connecticut; Elizabeth Mine, Vermont; Rowe, Massachusetts; Mineral City (formerly Tolersville), Virginia; and several localities in Georgia; also in Nova Scotia and on the north shore of Lake Superior (Sudbury), and in the Western States.

It is suggested that the sulphurous products from the roasting of copper ores and of zinc blende ores might be utilized, the latter being found largely in Southwest Missouri (Joplin) and Southeastern Kansas (Galena), Southern Wisconsin and Illinois (La Salle). It is also suggested that the gas works lime might be worked over for the sulphur it contains.

The residue from the process, sulphate of lime with resin gums, etc., combined, is of no value.

The outlay for mill and machinery in this process is said to range from $5,000 to $15,000 for each ton of daily product, and the cost of manufacture $30 per ton.

(*d*) *Electro pulp* is a product of most recent processes (developed by C. Kellner), in which the wood is digested in a solution of common salt at 250° to 260°, constantly electrolyzed.

Two digesters in communication are employed and the liquid is kept in continuous circulation from the electrolyzing vessel over the wood in the digesters and back to the electrolyzer, the latter a separate vessel in communication by means of pipes with both digesters.

The electric action splits up the salt into caustic soda and chlor-oxygen compounds; these latter, of well-known bleaching power, make the usual subsequent bleaching unnecessary and the process is said to furnish at once a "snow white" fiber. Under this class of processes belong also those pulping processes which employ chlorine gas as a disintegrator rather than a bleaching agent. The effect of the chlorine gas or its active oxygen compounds is to oxydize the incrusting substances so that they become soluble in very dilute alkali liquors without the need of higher temperatures.

The bleaching is done, as a rule, by the use of hyposulphite or bleaching powder, which is mixed with the pulp in varying quantities.

Lately an electro-chemical bleaching process (E. hermite) seems to have been brought to perfection, in which a weak (5 per cent) solution of magnesium chloride is electrolyzed. The chlorine developed acts as a bleacher and then combines again with the base, so that the same liquor can be used over and over again, the cost of the motive power for the electric machine being the only expense. The elaborate plant is objected to. (See Journal of Society of Chemical Industry, London, 1890, containing one paper in vindication (Cross & Bevan), and another against the process (Hurter.) A further improvement of this process consists in adding a small proportion of quicklime to the salt solution, whereby it is claimed the electro-motive force may be reduced and other advantages gained.

To estimate the commercial value of these various processes three points, it seems, ought to be considered: (1) The resulting product as to quality and yield; (2) the cheapness and convenience of the necessary plant and chemicals; (3) the application to various woods.

Ample water power and clear water, supply of suitable woods with large proportion of cellulose, long felting fiber, and requiring least expense in freeing it from incrustations, are the conditions, in addition to those which favor any other commercial enterprises, to be looked for in locating plants. I would especially point out in the interest of forest management and forest supplies that an adaptation of the plant to the simultaneous use of the various woods offered, combining those of long and short fiber, will have to be the study of the future.

The material obtained by the different processes differs in quality and quantity and answers different purposes.

The *ground pulp* is naturally of short fiber, and while without addition of a long, elastic, and felting fiber, only short (brittle) paper can be made from it, for a filling material of better classes of pulp in the manufacture of ordinary cheap paper and cardboard it answers very well, giving body and capacity. Common newspaper consists of 80 per cent of ground pulp.

The yield should be 1 pound per horse power per hour of dry stuff and about 19 pounds per cubic foot of wood where spruce and fir are used. The larger yield reported—namely, 2,000 pounds to the cord—refers either to a very well measured cord or else to material not thoroughly air-dried. The plant is naturally cheap and with pure water and sufficient fall of the same is easily put up and run economically. The wood need not be as clean as for the chemical processes, inferior material being satisfactory, although branch knots must be removed as they discolor the pulp, and rotten wood can not be used. The better class of firewood answers very well. All woods can be used for this process, but the harder woods require more power, and hence are less economically worked, so that now mostly conifers are ground; also aspen, poplar, cottonwood, basswood, birch, buckeye, and gum.

The *brown pulp*, which seems not to be made in this country, yields a much longer and better felting fiber, since by the steaming process a part of the incrustation is dissolved and the fibers are loosened, and hence not so much lacerated in the grinding. Since, however, the dissolved compounds impart a dark color to the pulp, it can be used only for brown papers. It makes, however, an excellent, tough packing paper and strong pasteboard. Attempts to remove the brown color by boiling in dilute oxalic acid have so far been only partially successful. A process by which the wood is boiled in hydrosulphuric alkalis with subsequent washing in hot water seems to be more successful in yielding a whiter material capable of treatment with bleaching powder. The salts can be recovered and used again, while the brown liquor of solved materials may be worked advantageously for wood alcohol, so that this process promises much economy. The yield of pulp under favorable conditions is said to be as high as 70 per cent in weight of the wood, which is the highest claimed for any process.

The chemical processes furnish the best material, but since the chemicals under higher temperatures attack and dissolve part of the cellulose itself, the yield is considerably less than from the mechanical and partly chemical processes. While the electric process is as yet in its infancy, there can hardly be any doubt that it will be rapidly developed and eventually supersede all other processes, since it involves no other expenditure than that for motive power and promises to yield a superior product.

The *soda pulp* is similar to that from cotton rags, of greater softness and opacity than the acid pulps, but the yield is rather low on account of the strong action of the chemicals on the cellulose; thus, while the bisulphate may yield 45 to 50 per cent from white pine, the soda process would yield only 33 per cent, or 800 to 1,000 pounds per cord. The present low cost of soda and the easy and cheap method of recovery from the spent liquor by evaporation and calcination, in which latter operation the fuel is supplied by the dissolved organic matter, are factors of economy which may offset the lower yield.

The *sulphate pulp* yields a paper similar in quality to that from soda pulp, perhaps somewhat better, approaching linen paper. The

objectionable smell and the economic features of this process have been pointed out before. The absence of tank wastage is particularly noticeable. It is also claimed that it bleaches far better and with half as much bleaching material as other processes in the market. It is probably classed with either soda or sulphite pulps.

The *sulphite pulp* is harder and more transparent than the pulp obtained by alkaline treatment. It may be used without further bleaching for tinted and low white paper, but to produce a fully white material like soda pulp 15 to 30 per cent its own weight of bleaching powder is required. The yield should be 40 to 50 per cent, but from the reports it would appear that the practice in this country brings hardly more than the soda process. With the residual liquor an entire loss, and no special features of superiority, it is questionable whether this process, although at present on a boom and enormously extended, will ultimately maintain its high position Especially when it is considered with reference to wood supplies, it can not be expected to supersede the alkaline processes.

ADAPTATION OF WOODS.

The soda and sulphate processes can utilize much more resinous and knotty woods or parts of trees because the resins combine with the alkalis to form soaps soluble in water and hence easily washed out, while the acid processes, like the sulphite, dissolve the resins only partially, and are, therefore, preferably used for young growth and sapwood, leaving the older heartwood intact, although it is claimed that the knots in spruce and balsam fir soften as readily as the rest of the wood; but the heart of the Norway pine and probably of the more resinous pines of the South would not yield to this treatment.

The fibers of conifers resemble those of cotton, are of considerable length, flat, tape-like, and flexible, which characteristics impart to them superior felting quality.

The deciduous woods are most readily acted upon by the solving liquids, and some of them, poplar, aspen, tulip, and basswood, especially excel by their white color; they would, therefore, form a most desirable raw material if their shorter fiber were not objectionable. The cells being in the average only about one tenth of an inch in length, tubular and pointed, they do not make a good felting pulp, although they are quite flexible, and hence even the chemical pulp of these woods, with few exceptions, is used only as filler. A further study of our native hard woods, with reference to their fiber, is, however, still desirable before classing them all as second for pulp material.

The poplars, which have the longest fibers of those so far used, have the advantage of a persistent white color, while basswood, next in value, takes a reddish tint, birch a pink, and maple a purple hue, which makes it objectionable; larch is said to color very badly. Spruce, balsam fir, hemlock, jack pine, cedar in the North, loblolly pine, and cypress in the South are at present staples. The spruce especially furnishes at present the bulk of pulp manufactured in this country, a frequent practice being to add some poplar or aspen pulp for the purpose of whitening the spruce pulp.

It is said that trees twenty-five to thirty years old are best for grinding, that evenly grown wood is the most desirable, and that trees from marshy ground are not acceptable. The wood must be

freshly cut, as too much exposure to the air hardens the fiber by drying. By keeping the wood in the water until ready to use it, not only is it kept softer, but some of the resinous substances are leached out.

If prices give a correct estimate of values, the chemical pulp is about two and two thirds times superior to mechanical pulp. For the sake of comparison the following quotations are here given:

	At London.	At New York.	Domestic.	Tariff.
Ground pulp (pine), dry, per ton	$24.00	$30.00		
Ground pulp (aspen), dry, per ton	40.00	35.00	$26.00- 28.00	$2.50
Brown pulp, dry, per ton	30.00			
Soda unbleached	$50.00-60.00	$54.00-61.00		6.00
Soda bleached	67.50	70.00-78.00	70.00- 75.00	7.00
Sulphite unbleached	50.00-75.00	54.00-71.00	75.00- 80.00	6.00
Sulphite bleached	82.00-88.00	85.00-95.00	90.00-100.00	7.00
Wood flour		27.00	30.00	

Making the average yield per cord 1,700 pounds for ground, 1,000 for sulphite, and 800 for soda pulp. By the different processes the value of a cord of wood may be brought to $24.50 or $30, respectively.

From the compilations of the Paper Trade Journal (Howard Lockwood, New York), the growth of the industry for the last nine years can be learned:

Growth of daily capacity of running wood pulp manufacture.

	Chemical fiber.	Ground wood pulp.
	Pounds.	*Pounds.*
1881	259,500	484,300
1883	466,000	633,450
1884	576,000	795,550
1885	587,000	835,830
1886	537,000	960,600
1887	602,000	1,085,900
1888	617,000	1,536,500
1889	866,500	2,607,600
1890	1,576,500	2,900,700

This would show that the business has increased nearly 500 per cent in the last eight years and nearly 200 per cent in the last four years.

In 1888 the stumpage consumed for pulp was valued at $2,235,000. The product, 225,000 tons ground and 112,500 chemical pulp, was valued together at $12,375,000, the capital employed being estimated at $20,000,000. The figures given below would indicate a present consumption in round numbers of 1,000,000 cords of wood per annum. When it is considered that about 1,000,000,000 pounds of book and news paper are consumed annually in this country, two thirds of which might be made of wood fiber, there is still a considerable margin for this use alone to be supplied by wood pulp.

In reply to the question what the Department might do for the pulp makers' interests, the need of stopping the firing of the woods is most prominently mentioned. The planting of trees, bounty for such planting, or distribution of plant material, are also suggested. Railroad facilities, tariff protection, and reports giving reliable information are asked for by others.

Statistics of the wood pulp industry of the United States, 1890.

(*a*) NUMBER OF MILLS IN OPERATION AND THEIR CAPACITY

States.	Mechanical (ground) pulp.			Chemical (soda) fiber.			Chemical (sulphite) fiber.			Mechanical and chemical combined.		Total.	
	Number of mills.	Capacity, daily.		Number of mills.	Capacity, daily.		Number of mills.	Capacity, daily.		Number of mills.	Capacity, daily.	Number.	Capacity.
		Range in 1,000 pounds.	Total.		Range in 1,000 pounds.	Total.		Range in 1,000 pounds.	Total.				
Maine	15	2.5–70	407,500	4	20–52	149,000	5	16–30	106,000			24	662,500
New Hampshire	15	4–30	220,500	2	60	60,000	1	10	10,000			18	290,500
Vermont	17	2–80	273,500				1	8	8,000			18	281,500
Massachusetts	3	4–10	21,000	1	11	11,000	3	8–20	43,000	1	40,000	8	115,000
Connecticut							1		11,000			1	11,000
New York	67	1.5–80	855,800	4	8–55	117,000	3	16–30	76,000	1	6,500	75	1,055,300
Pennsylvania	3	6–20	42,000	7	6–80	233,000	1		25,000			11	300,000
Delaware				1	44	44,000						1	44,000
Maryland	1	25	25,000	1	27	27,000	1		20,000			3	72,000
Virginia	2	12–18	30,000									2	30,000
West Virginia	3	30–30	84,000				1		50,000			4	134,000
North Carolina	3		7,000									3	7,000
South Carolina	1		2,500									1	2,500
Georgia	5	.6–4	11,850									5	11,850
Kentucky	1		22,000									1	22,000
Ohio	2	8–10	30,000	1		7,500	2		30,000			5	67,500
Indiana	11	1.5–40	129,500	1		30,000						12	159,500
Michigan	8	3–24	67,000	1		8,500	4	4–30	72,000			13	147,500
Wisconsin	21	6–30	310,000				5		74,000			26	384,000
Minnesota	2	2–20	22,000									2	22,000
Oregon	2	8–40	48,000				1		20,000			3	68,000
California	1		40,000									1	40,000
Total	183		2,649,150	23		687,000	29		545,000	2	46,500	237	3,927,650

NOTE.—In addition to the above 237 mills, which number represents nearly all at present in operation, there are reported 14 idle and 2 abandoned. From Canada 33 pulp mills are reported, 24 of which have a daily capacity of 276,800 pounds.

(*b*) SUPPLIES AND PRODUCT.

States.	Number of mills.	Kinds of wood used.	Range of yield, per cord, in hundreds of pounds.			Number of mills reporting supplies.					Remarks.
			Mechanical.	Soda.	Sulphite.	Good.	Fair.	Limited.	Declining.	Poor.	
Maine	12	Spruce only or chiefly	16–20		11–13.5	20	1				
	7	Spruce and poplar	15–20	10							
	1	Spruce, poplar, and pine									
	1	Poplar		10.3							
New Hampshire.	13	Spruce only or chiefly	18–24.5		10	11	2	2			1 get supplies mostly from Canada.
	2	Spruce and poplar		10							2 get supplies partly from Canada.
Vermont	11	Spruce only or chiefly	18–20			11		4	1	1	1 gets supplies mostly from Canada.
	5	Spruce and poplar	20–23								
	1	Poplar and pine	20								
Massachusetts.	4	Spruce only or chiefly	15–22		10	5				3	2 supplies from Northern Vermont and New Hampshire.
	4	Spruce and poplar	17–18								

Statistics of the wood pulp industry of the United States, 1890—**Continued.**

(*b*) SUPPLIES AND PRODUCT—Continued.

States.	Number of mills.	Kinds of wood used.	Range of yield, per cord, in hundreds of pounds.			Number of mills reporting supplies.					Remarks.
			Mechanical.	Soda.	Sulphite.	Good.	Fair.	Limited.	Declining.	Poor.	
Connecticut	1	Spruce								1	Supplies from New Brunswick and Nova Scotia.
New York	52	Spruce only or chiefly	15–22		13	34	7	8	2	2	1 supplies mostly from Canada.
	4	Spruce and poplar	16–20								15 supplies from Canada or distant points.
	1	Spruce and hemlock			11						
	1	Spruce, hemlock, bass			10						
	2	Spruce, poplar, and pine									
	2	Poplar	14	9							
	1	Poplar, bass, pine, and spruce.		10							
	1	Spruce and pine									
Pennsylvania	2	Spruce only or chiefly	19–20			1		1			
	1	Spruce and poplar			10					1	Supply from West Virginia and Nova Scotia.
	2	Poplar		10						2	Supply from Maryland and Virginia.
	2	Poplar, bass, pine		9–10			2				
	2	Poplar, bass, pine, maple		7–12			2				
	1	Hemlock, pine, beech, bass.		10		1					
	1	White pine	16			1					
Maryland	2	Spruce only or chiefly	18		10	1	1				Spruce from West Virginia and Canada.
	1	Poplar		10		1					
Delaware	1	....do						1			
Virginia	2	....do	20			2					
West Virginia	4	Spruce only or chiefly	17		10.5	2	2				
North Carolina	2	Pine	10				2				
South Carolina	1	Cypress and gum					1				
Georgia	3	Pine	20–27			3					
	1	Cypress and gum				1					
	1										
Kentucky	1	Spruce, buckeye, and maple.	18				1				
Ohio	2	Spruce only or chiefly	17			2					
	1	Cottonwood and bass		9	10		1				
Indiana	3	Aspen	16			1		1		1	
	1	Spruce and poplar	16				1				
	2	Poplar, spruce, pine	12					1		2	
	1	Aspen, poplar, cottonwood.	1[illegible]							1	
	1	Cottonwood	20					1			
	1	Basswood		9		1					
Michigan	4	Spruce only or chiefly	16		8–10	1	2			1	1 supply all from Canada.
	3	Poplar	16–20	15		2		1			
	4	Poplar, pine, tamarac, spruce, and balsam.				4					
	1	Aspen, pine, poplar, spruce, and bass.	14						1		
Wisconsin	4	Spruce only or chiefly	16–18		9–10	1	2		1		
	15	Spruce and poplar	13–15		9–10	5	5	2	1	2	
	4	Spruce, poplar, pine	10–12			1		1	2		
Minnesota	1	Spruce only or chiefly	15					1			
Oregon	1	Cottonwood				1					
California	1	Tamarac and fir	17			1					

TIMBER TESTS.

While the use of wood pulp and other substitutes may displace in many ways the use of wood in its natural state, there will always be desirable qualities inherent in the latter that make its use indispensable. Hence the desirability of knowing the qualities of our timbers and, if possible, of knowing the conditions under which the wood crop will develop the desirable qualities.

Much work and useful work is done in the world by the rule of thumb. All such work is not reliable and certainly not economical. With the need of greater economy in production, the need of more accurate measuring arises, and with that the need of more specific knowledge of the materials to be measured.

Wood is one of the materials which has been measured by the rule of thumb longer than others. Iron and other metals used in the arts have their properties much more accurately determined than wood material. Especially in the United States, when we speak of quality of our timbers, it can only be in general terms; we lack definite data.

One difficulty in determining reliably the qualities of our timbers lies in the fact that living things are rarely precisely alike. Every tree differs from every other tree, and the material taken from the one has a different value from that taken from the other of the same species. Yet every tree has some characteristics in common with all those grown under similar conditions. But even these common properties differ in degree in different individuals. Individual variation tends to obscure relationship.

The factors which determine the quality of timbers are found directly in the structure of the wood, and it is possible from a mere ocular examination to judge to some extent what qualities may be expected from a given piece of timber, although even in this direction our knowledge is very incomplete, and but few definite relations between structure and quality, or between physical and mechanical properties, are established. We know that the width of the annual rings, their even growth, the closeness of grain, the length, number, thickness, and distribution of the various cell elements, the weight, and many other physical appearances and properties of the wood influence its quality, yet the exact relation of these is but little studied. Conjectures more or less plausible, suppositions, and a few practical experiences preponderate over positive knowledge and results of experiments. Again we know, in a general way, that structure and composition of the wood must depend upon the conditions of soil, climate, and surroundings under which the tree is grown, but there are only few definite relations established. We are largely ignorant as to the nature of our wood crop, and still more so as to the conditions necessary to produce desirable qualities, and since forestry is not so much concerned in producing trees as in producing quality in trees, to acquire or at least enlarge this knowledge must be one of the first and most desirable undertakings in which this Division can engage.

Accordingly a comprehensive plan has been put into operation to study systematically our more important timber trees.

It will at once be understood that as long as the qualities are to be referred to the conditions under which the tree is grown the collection of the study material must be made with the greatest care,

and the material must be accompanied with an exhaustive description of these conditions. Since, further, so much individual variation seems to exist in trees grown under seemingly the same conditions, a large number must be studied in order to arrive at reliable average values. For the present it has been decided to study the pines, especially the white pine and the three southern lumber pines.

In selecting localities for collecting specimens, a distinction is made between station and site.

By station is understood a section of country (or any places within that section) which is characterized in a general way by similar climatic conditions and geological formation. Station, then, refers mainly to the general geographical situation. Site refers to the local conditions and surroundings within the station, such as difference of elevation, of exposure, of physical properties and depth of the soil, nature of subsoil, and forest conditions, such as mixed or pure growth, open or close stand, etc.

The selection of characteristic sites in each station requires considerable judgment.

On each site five full grown trees are to be taken, four of which are to be representative average trees; the fifth or "check" tree, however, should be the best developed tree that can be found on the site. Some additional test trees will be taken from the open and also a few younger trees. The trees are cut into varying lengths, and from each log a disk of 6-inch height is secured after having marked the north and south sides and noted the position of the log in the tree.

The disks are sent for examination of the physical and physiological features to the Michigan University, while the logs, and later on special parts of the disks are to be sent to the test laboratory of the Washington University of St. Louis. Here, for the first time, a systematic series of beam tests will be made and compared with the tests on the usual small laboratory test pieces. Such tests with full length beams in comparison with tests on small specimens promise important practical results, for a few tests have lately developed the fact that large timbers have but little more than one half the strength they were credited with by standard authorities, who relied upon the tests on small specimens.

From the "check" tree mentioned before only clear timber is to be chosen, in order to ascertain the possibilities of the species and also to establish, if possible, a relation between such clear timber and that used in general practice, where elements of weakness are introduced by knots and other blemishes.

An authority on engineering matters writes regarding this work:

> Inasmuch as what passes current among engineers and architects as information on the strength of timber is really misinformation, and that no rational designing in timber can be done until something more reliable is furnished in this direction, the necessity for making a competent and trustworthy series of such tests is apparent. This is a work which the Government should undertake if it is to be impartial and general.

A careful record of all that pertains to the history and conditions of the growth from which the test pieces come, and of their minute physical examination, will distinguish these tests from any hitherto undertaken on American timbers.

The disk pieces will be studied to ascertain the form and dimensions of the trunk, the rate and mode of its growth, the density of the wood, the amount of water in the fresh wood, the shrinkage consequent upon drying, the structure of the wood in greatest detail,

the strength, resistance, and working qualities of the wood, and lastly, its chemical constituents, fuel value, and composition of the ash.

For this part of the work, which is the most laborious and difficult, Mr. Filibert Roth, of Ann Arbor, is engaged, having prepared himself for it by several years of preliminary study in that line. The testing will be done by Prof. J. B. Johnson, of St. Louis, whose facilities, central location, and interest in the work promise desirable progress. The collection of the southern pine specimens, which will occupy the greater attention of the work this year, is done by Dr. Charles Mohr, which assures a judicious selection of material and competent description of conditions of growth.

Thanks are due to the Louisville and Nashville Railroad Company and to the Chicago, Milwaukee and St. Paul Railroad and to the Chicago, Burlington and Quincy Railroad Companies, who in a generous manner have offered free transportation for test logs.

It is estimated that for the first series fifty trees will be studied, involving about two thousand tests and a large amount of laboratory determinations.

Incidentally with this line of work, at the request of the Committee on Timber Supply of the National Carriage Builders' Association, some tests of northern and southern grown oak for carriage stock were undertaken, the results of which are here reported.

Unfortunately it was not possible to secure the test material, or to carry out the tests as thoroughly as should have been done, in time for the desired report to the Carriage Builders' Convention. The following tests and examinations, therefore, are not to be considered as samples of what will be done, but only as indications of the kind of questions to be settled by this inquiry. It will be found that the descriptive part is not what it should be, and the number of tests is too small to allow generalization, yet some interesting results are nevertheless anticipated from these preliminary tests.

In the descriptive part the schedule, which is to be filled out for the more elaborate tests, is given in full in order to establish uniformity in description. A series of descriptive words appear in the schedule (as given for sample *a*), so that the collector needs only to underscore the suitable one.

(*a*) *Description of station, site, and trees from which test material was taken.*

I. Station:	A (Connecticut).	A.	B (Arkansas).
1. Average longitude....	73.		91.
2. Average latitude	41.30.		36.
3. Average altitude......	200 (?)		
4. General configuration.	Plain, hills, plateau, mountainous, general trend of valleys or hills.		
5. Climatic features.....	....		
II. Site:	*a*.	*b*.	
1. Aspect..............	Level, ravine, cove, bench, slope (angle of).		Specimens selected from stock in the yard of Woody, Holmes & Co., carriage stock manufacturers. History unknown. Supposed to represent fair average of first-class timbers that can be supplied in large quantities.
2. Exposure............			
3. Elevation above average station altitude.			
4. Soil conditions........	Upland....................	Lowland....	
(*a*) Geological formations.			
(*b*) Mineral compositions.	Clay, limestone, loam, marl, sandy loam, loamy sand, sand.		
(*c*) Surface cover	Bare, grassy, mossy; leaf cover abundant, scanty, lacking.		
(*d*) Vegetable mold, depth.			

(a) Description of station, site, and trees from which test material was taken—Continued.

I. Site—Continued.			
4. Soil conditions—Continued.			
(e) Grain, consistency, and admixtures.	Very fine, fine, medium, coarse, porous, light, loose, moderately loose, compact, binding, stones or rocks (size of).		
(f) Moisture conditions.	Wet, moist, fresh, dry, arid, *well drained*, liable to overflow, swampy, near stream or spring or other kind of water supply.	Wet	
(g) Color			
(h) Depth to subsoil	Shallow, 6 inches to 1 foot; 1 foot to 4 feet, deep; over 4 feet, very deep; shifting.		
(i) Nature of subsoil.			
5. Forest conditions:			
(a) Growth	Mixed, pure, dense, moderately dense, open.		
(b) Associated species			
(c) Proportion of these.			
(d) Average height			
(e) Undergrowth			
6. Conditions in the open.			
(a) Nature of surroundings.	Field, pasture, lawn, clearing (how long cleared).		
(b) Nature of soil cover.	Weeds, brush, sod		
III. Description of trees:			
1. Species	White oak	White oak	White oak.
2. Number	I	II.	
3. Special position (if not covered sufficiently by general description).			
4. Origin of tree	Natural seeding, sprout from stump, artificial planting, unknown.	Sprout	
5. Diameter (breast high).			
6. Height of stump			
7. Length of felled tree.			
8. Total height			
9. Height to first limb			
10. Age (annual rings on stump).			
11. Time when cut, and after treatment			

(b) Description of test material and results of physical examination.

Notation as to station, site, and tree	A. a. I.	A. b. II.	B.
Number of test piece	1.	3.	
Exposure in tree	North.	Southwest.	
Height in tree	"Butt cut."	"Butt cut."	
Position in tree (with reference to periphery)	Not known.	Not known.	
Size of test material:			
Length	4	4	
Breadth	1¼ inch.	1⅛ inch.	
Depth (measured across rings)	1⅛ inch.	1⅛ inch.	
Number of rings			
Width of rings (average)	2.7 millimeters.	1.5 millimeters.	
Summer wood as a whole	80 per cent.	54 per cent.	
Firm bast tissue	60 per cent.	37.5 per cent.	
Space lost by large vessels	14.7 per cent.	24.9 per cent.	
Moisture conditions when tested	Nearly seasoned.	Half seasoned.	
Density	.84	.77	

(c) *Results of tests made in Washington University Laboratory, St. Louis, Missouri, by Prof. J. B. Johnson.*

Test piece.		Bending and crossbreaking. Size of test piece 1⅝ by 1⅝ by 24.						Compression.				Shearing.	
		Stiffness.		Ultimate strength.		Resistance to shock.		Endwise.		Transverse.		Longitudinal.	
Where procured.	No.	Range No.	*Modulus of elasticity, pounds per square inch.	Range No.	Modulus $\frac{3.W.L.}{2.b.h^2}$ pounds per square inch.	Range No.	Modulus inch-pounds per cubic inch.	Range No.	Modulus pounds per square inch. Size 1⅝ by 5 inches.	Range No.	Modulus pounds per square inch.	Range No.	Modulus pounds per square inch.
A. a. I	1	9	990,000	3	13,760	4	59	6	6,160	1	3,400	3	1,375
	2	5	1,280,000	1	18,500	1	92	7	5,480	3	3,100	1	1,560
Average.	....	3	1,135,000	1	16,130	1	76	3	5,820	1	3,250	1	1,468
A. b. II	3	6	1,120,000	8	12,300	6	47	11	4,740	7	2,500	6	....
	4	10	920,000	5	12,700	5	55	9	4,980	4	2,800	7	1,225
Average.	....	4	1,020,000	3	12,500	3	51	5	4,860	2	2,650	3	1,225
	5	11	850,000	9	11,400	2	83	8	5,230	5	2,700	4	1,375
	6	7	1,140,000	7	12,300	7	45	10	4,820	8	2,500	2	1,540
Average.	....	5	995,000	5	11,850	2	64	4	5,025	3	2,600	2	1,458
B		Size: 1⅝ by 1⅝ by 18 inches.						Size: 1⅝ cube.					
	7	3	1,570,000	6	12,380	9	27	4	6,800	11	2,000	10	860
	8	8	1,100,000	2	14,690	3	82	1	7,800	2	3,200	5	1,260
	9	4	1,385,000	11	11,240	11	19	5	6,800	9	2,300	11	825
Average.	....	2	1,351,667	2	12,770	4	43	2	7,133	4	2,500	5	982
	10	1	1,653,000	4	13,030	8	30	3	6,900	6	2,600	8	1,050
	11	2	1,581,000	10	11,590	10	22	2	7,700	10	2,100	9	940
Average.	...	1	1,617,000	4	12,310	5	26	1	7,300	5	2,350	4	995

*Young's modulus of elasticity: $E = \frac{W.L.^3}{4\,D.b.h.^3}$ where
W. = total load at center in pounds.
L. = length in inches.
D. = deflection in inches.
b. = breadth in inches.
h. = height in inches.

As stated before, these tests can hardly settle definitely any question. Samples 1 and 2 being selected stock, second growth, can not be used for comparison with samples of B, except to show that for stiffness the unselected southern stock is superior to the best northern growth, as also in resistance to endwise compression. The samples 3, 4, 5, and 6 are probably more nearly comparable to samples of B, and here we find the southern oak very much superior, not only in stiffness and columnar strength, but also in ultimate cross-breaking strength, while for resistance to shock at least one sample of southern oak is superior to three samples of forest-grown northern, and even to one of the best northern second growth. This piece (No. 8) exhibits, altogether, qualities which render the verdict tenable that southern oak is not necessarily inferior to northern oak in any of its qualities.

Beyond this it would not be safe to use these figures for generalizations. From Mr. Roth's examination of the two northern oak samples we learn that the time taken to lay on the same amount of

wood which the open-grown upland oak made in one year was, in the forest-grown lowland oak, 21.5 months, showing the former superior from the forest economical point of view as it is also from the wood consumers' standpoint.

Comparing these two sticks with reference to density they would stand as 5 to 4, while comparing the relative amounts of firm bast and spring wood the ratio would be 8 to 5; and Mr. Roth argues that the former ratio would probably give more nearly a comparison for strength and stiffness, while the latter should be considered as the proper ratio regarding the value of the two sticks for wagon spokes. In reality the tests for stiffness, if the modulus of elasticity is considered to indicate stiffness, proved the ratio to be nearer 6 to 7, the first stick showing least stiffness. The tests for cross-breaking strength establish a ratio of 6 to 5, while the ratio of resistance to endwise compression corresponds to the density ratio.

Resilience (resistance to shock), which Professor Johnson takes as the nearest expression of the quality called toughness, showed the ratio of 6 to 5. From these single tests we do not, therefore, derive an unmistakable relation of physical and mechanical properties.

FORESTRY INTEREST IN THE STATES.

While it may not be possible to point to any particular development as a sign of progress in the forestry movement, the indications that greater interest is felt throughout the country in the endeavors of the friends of forestry reform have become more frequent with every year. One of the most promising signs is the frequent discussion of forestry matters, not only in the general press, but especially in the papers devoted to the interests of the lumber business. These papers, as well as lumbermen at large, begin to recognize that the time is nearing when methods of obtaining the supplies for the lumber business must be modified so as to secure, instead of preventing, natural reforestation of the better kinds. How the present methods of lumbering reduce the chances of desirable natural reforestation will appear further on.

There are now holders of large timber areas who would be willing to follow a rational policy in regard to their lumbering operations if they knew how to do it. Since conditions vary so greatly, it would be impossible to give information in this respect capable of general application. On the other hand the presentation of what is involved in forest management, in a definite, concrete case, may aid in forming some idea of the manner in which other conditions may be satisfied.

I am fortunately able to furnish such reference to a definite case of proposed forest management, which, in my estimation, marks a new era in the forestry movement. I refer to the purchase by the Adirondack League Club of a large area of virgin timber lands (some 93,000 acres) in the southwestern part of the Adirondacks, with the stated purpose of placing it under forest management. As a proof of the bona fide intention of the club, I may say that the direction of the forest policy of the club was confided to the present writer. I deem this move such an important one, and the opportunity of teaching forestry principles in their application to a definite object so welcome, that I ask leave to reproduce here such parts of my report to the executive committee of the club as may be of general interest

and helpful in inducing other proprietors of woodlands to apply as far as practicable similar principles.

To the Executive Committee of the Adirondack League Club, New York:

* * * * * * *

The club is to be congratulated on two things; first, on the laudable intention of practically applying, for the first time in the United States, forestry principles to the management of its woodlands, and secondly, on the excellent opportunity for such application offered in its valuable property, combining as it does the three essential conditions which may render profitable forest management in the United States at the present time possible, namely, a sufficiently large and compactly situated area, a large amount of available and valuable material uninjured by fire or otherwise, and proximity to large centers of consumption, to which it can be made accessible.

THE PROPERTY.

You have been fortunate in securing in a tolerably compact body one of the best-wooded, absolutely virgin timber tracts of the Adirondack region, situated in the southwestern outskirts of the mountain region proper, within easy reach of Albany and New York, the largest lumber markets of the East, with waters—the headwaters of Black River and of the Mohawk (West Canada Creek)—capable of floating the soft woods, and with a topography which admits of easy grades for roads and railroads, and presents no serious difficulties of any kind for carrying on lumber operations and forest management.

As far as examined the property represents a hill country, well watered, with gentle slopes and no elevations more than 500 or 600 feet above the mean altitude of about 2,000 feet above sea level. The soil is a sand of moderate depth, overlying the native rock, richly impregnated with the products of humification from the fallen foliage of centuries and then covered with "duff," resulting from the imperfect humification of the spruce needles. It is a soil, which, when exposed and put into cultivation, soon shrinks and deteriorates, having no durability for agricultural use, but which if kept carefully under forest cover, forms a most excellent basis for tree growth and forest management.

The forest consists principally of birch* and maples† of magnificent proportions with the admixture of beech and black spruce.‡ There occur on the tract also, although rarely in large numbers, except in a few localities, white pine, balsam fir, tamarack, hemlock (the latter sometimes of large size and in predominant quantity), and hard woods, single trees of black cherry, elm, and in low places, black ash. None of these or of the few other species found need to be at present considered in the forest management, which will have to concern itself primarily with the birch, maple, and spruce. The ratio in which these kinds occur may be roughly estimated as averaging 40 per cent for the birch, 30 per cent for the maple (hard maple predominating) and beech, and 25 per cent for spruce, leaving, say, 5 per cent for the other timbers.

* * * * * * *

The beech, although numerically equal to the maples, shows an inferior development and small diameter, and is for that reason hardly to be counted among the principal growth. It may, in fact, become rather troublesome in the forest management, owing to its superior capacity for reproduction under the prevailing light conditions, thus excluding the more desirable kinds.

The quantities of merchantable timber per acre, it would, of course, be impossible to state from such a superficial inspection as was afforded the writer. But from what could be seen in a four days' tramp through the woods, I should be inclined to consider an average yield of 6,000 feet of spruce (above 12 inches) and enough of birch and maple to make altogether 15,000 to 20,000 feet of merchantable timber per acre a fair estimate. This refers, of course, only to the fully matured timber. There is also a large amount of "down timber," fallen trees, of which the sapwood only is defective, and which will increase the yield considerably.

As is the rule in a virgin forest, trees of all sizes and ages occur side by side. It is, however, noticeable that really young growth occurs very rarely, owing to the fact that the old growth has very dense and shady crowns, shutting out the light

*Two species: *Betula lenta*, the black or cherry birch, and *B. lutea*, the gray or yellow birch.

†*Acer saccharum*, the hard or sugar maple, and the two soft maples *A. saccharinum* and *rubrum*.

‡*Picea mariana*, formerly called *nigra*.

so essential to a proper development of the young plant. The apparently young growth of spruce especially, which is found here and there through the woods, is in fact nothing more, in most cases, than stunted growth of considerable age, which has been capable of persisting and vegetating under adverse light conditions.

To get at an approximate valuation of the property as a wood producer the following calculation might be ventured: Allowing of the total area say, in round figures, 70,000 acres as fully productive, and taking 15,000 feet of merchantable timber standing per acre, I estimate the stock available, at present figures, as 1,050,000 M feet, board measure, worth on the stump, at present minimum price, a round million dollars. Allowing a rotation of one hundred years as desirable in which to cut over and reproduce this area—a shorter rotation would probably be quite practicable—the annual cut in the old stock would yield 10,500 M feet. To this must be added an accretion of 350 feet per year to the acre, an exceedingly conservative estimate, representing over the entire area 24,500 M feet of annual growth, so that the property would be capable of yielding annually for the next one hundred years, and practically forever, at least 35,000 M feet of lumber, which, figured at the present minimum price on the stump, means an annual income of $35,000.

* * * * * * *

It should, of course, be understood that an annual cut exceeding the above figure is by no means objectionable, as long as old stock is on hand and due regard is given to reproduction. An annual cut of the same amount in material, or in value only, from year to year, presupposes that it is desirable to have a regular dividend of nearly even amount instead of irregular ones. If need be, and if the conditions of the market make it appear more profitable, there can be no objection to increasing the cut, reducing it proportionately afterward.

THE CONTRACT.

The club acquired its property with an undesirable liability upon it, which is bound more or less to handicap its endeavors in the introduction of forest management. I refer to the contract under which a certain lumber firm obtained the right to cut during the next fifteen years all the spruce above 12 inches in diameter on any part of the property without any restrictions. While as a matter of financial expediency this contract may have been desirable, it was, I understand, an unavoidable condition in the purchase. As a matter of forest policy, the club can not flatter itself on having inaugurated any advance upon methods already existing. Aside from the facts that this contract confers a most valuable privilege at an exceedingly low figure, and takes out of the hands of the club the unrestricted control of the property, from a technical point of view it can not be considered good forestry. Lumbermen in various parts of the country have before this abstained from taking all the cream at once, mainly because it did not pay, and having left certain sizes of certain timbers uncut, have found and cut a "second crop" after a number of years, the smaller sizes having grown to fair dimensions.

Friends of forest preservation in their recommendations, and the commissioners of Crown lands in Canada in practice, have made the size down to which timber might be cut a condition of forest conservancy. It can not be denied that by restricting the cut to special timbers and sizes presumably absolute clearing is avoided, and the absolute exhaustion of the particular kinds of timber on the area prevented or at least delayed, and in so far as these two contingencies are attained there is a benefit in this restricted utilization. But these contingencies are matters of chance rather than of certainty, and the main object of forest management, namely, reproduction of the valuable timbers, is to a large extent, if not entirely, overlooked and frustrated. For, as I shall presently show, by culling out, as is done under your contract, the best of the spruce, this species is at once placed at a disadvantage as against those left on the ground. It is questionable whether any openings made in this culling process would seed themselves to spruce rather than to the prolific birch and maples, and even if a young growth of spruce should sprout up, would it find suitable light conditions to maintain itself? I repeat again that most of the spruce growth remaining after cutting would be not young growth but stunted trees which had been vegetating in the shade of the older timber.

A restriction in the number of trees per acre which might be cut or which might be left would have more show of rational conservancy, but even so the demands of a proper forest management would not be satisfied.

If it is considered desirable, as it decidedly should be, to foster and reproduce the spruce growth, it will be necessary to cut and utilize a part of the hard woods simultaneously—possibly before the spruce is cut—and the time and manner of cutting either will determine the manner of reproduction. The cutting must be done with a view to favor reproduction, and not in the haphazard way in which the lumberman does it. Here comes in the science of forestry.

A LESSON IN FORESTRY.

* * * * * * *

That foresty is a business carried on for profit seems still to be a matter unknown to many who talk and write on the subject. As agriculture is practiced for the purpose of producing food crops, so forestry is concerned in the production of valuable wood crops, both attempting to create values from the soil. Other conditions like the preservation of climatic, soil, or favorable water conditions, which are claimed for the forest cover, may influence and *modify the manner* in which the primary object of forestry, namely, production of wood crops and profits, is attained, but they do not necessarily exclude this primary object. In fact, the demands of forest preservation on the mountains, and the methods of forest management for profit in such localities, are more or less harmonious; thus the absolute clearing of the forest on steep hillsides which is apt to lead to desiccation and washing of the soil is equally detrimental to a profitable forest management necessitating as it does replanting under difficulties.

Forest preservation does not, as seems to be imagined by many, exclude proper forest utilization, but on the contrary may well go hand in hand. Forestry in a wooded country means utilization of the wood crop in such a manner that it will reproduce itself in the same, if not in a superior composition of kinds, as the original growth. Reproduction, then, is the aim of the forest manager, and the difference between the exploitations by the lumberman and by the forester consists simply in this, that the forester cuts his trees with a view of securing desirable reproduction, while the lumberman cuts them without this view, or at least without the knowledge as to how this reproduction can be secured and directed at will.

The efficient forest manager requires no other tool than the ax or saw; he has missed his highest aim when it becomes necessary to use the planting tools, unless, indeed, he meant to introduce new species, which were not at all or not in sufficient number to be found in the original growth, or unless clearing and subsequent replanting appears the more profitable and more successful method of reproduction. In hilly and mountainous country this latter method is for various reasons not desirable, hence management for natural reproduction by proper use of the ax should here form the rule.

How is this reproduction secured? To understand this it is necessary to realize that as in the animal world so in the vegetable there is a constant struggle for existence and supremacy going on among the different species as well as among the individuals of the same species. All struggle for the occupancy of the soil. The weapons with which this struggle is carried on are various, offensive and defensive. This species seeks to gain foothold by prolific annual seed production, aided perhaps by the lightness of the seed, which is wafted by the winds for miles in all directions; the ubiquitousness of the aspen wherever an open space affords light, is accounted for by this capacity.

Another species by its dense foliage shades the ground so that no rival can find favorable conditions of existence underneath; such are firs and spruces. Others again maintain themselves by developing a vigorous root system, which enables them to endure the shade of the superior growth, vegetating poorly, but biding their time until other agencies have decimated the enemy, ready then to occupy the field. The oak is an example of this kind. The alternation in forest growth, so often looked upon as a mystery, is thus accounted for. Man by fire or ax, nature by tempests and insect pests removing the superior growth, the species which persisted under the shade of the former and escaped or resisted the destructive agencies will occupy the ground.

Especially the different requirements in regard to light conditions and the relative rate of height growth, by which the species may or may not escape suppression by its neighbors, influence the temporary local distribution of plants and are of greatest interest to the forest manager. Light is one of the essential factors of tree growth and almost the only one which man can regulate. Forest management, then, could almost be defined as management of light conditions. The leaves exercise their functions under the influence of light and feed the tree by assimilating the carbon of the air. Such thinly foliaged trees as the aspen and some of the birches and others can only exist under a full complement of sunlight; they are, therefore, endowed with a rapid rate of height growth to enable them to grow quickly out of the danger of being overshadowed by their neighbors. Other species, like the firs, and in less degree the spruces, with a dense foliage and a large number of leaves, can be satisfied with less light and are as a rule slower growers; other kinds again, like the oak, while dependent for their full development on a large amount of light, probably by virtue of specially vigorous root action, can persist in the shade for a long time until more favorable light conditions allow thrifty growth. Especially

are the young seedlings of most kinds very sensitive in regard to light conditions and some have such a small range of light and shade endurance, that while there may be millions of little seedlings sprouted, they will all perish, if some of the mother trees are not removed and more light given; and they will perish equally, if the old growth is removed at once and the delicate leaf structure under the influence of the direct sunlight and heat is called upon to exercise its functions beyond its powers.

We, can, then, understand that not only the different species, but the same species at different periods of life, make varying demands in regard to light conditions; and the art of the forest manager in securing reproduction as well as in other operations, thinnings, etc., consists mainly in a proper regulation of light conditions by a proper and timely use of the ax.

The composition of the forest, climatic, soil, and moisture conditions modify again the requirements, so that all general rules of management need to be modified according to local conditions; and it will appear at once that a considerable exercise of judgment born of experience and knowledge is expected of the forest manager.

To further elucidate these and some other considerations involved in forest management, let me briefly trace the manipulations with reference to a specific case, in the reproduction, for instance, of the beech, as practiced over large areas in Germany. The beech, like many other timbers, bears seed only periodically. Seed years occur in different localities at periods varying from three to even twenty years, records of their occurrence being kept. A few years before the seed year is expected to occur the forest is somewhat thinned out to admit air and light upon the soil, in order that the litter of the forest floor be more rapidly decomposed and humified and so may form a suitable seed bed for the sprouting of the seed and also to stimulate the mother trees to a plentiful production of superior seed. In this thinning the inferior material and the undesirable kinds are first removed and such kinds as reproduce themselves easily without aid from the forester. When the nuts fall pigs may be driven into the woods to plow them under. Under favorable conditions a soft green carpet of young beech seedlings will be found to cover the ground in the Spring next after the seed year.

Now comes the critical period. If the mother trees were left the whole crop would be lost, and while waiting for the next seed crop under the altered light conditions, which invite grasses, weeds, and other species to come in, the difficulties in securing reproduction are increased. By thinning out gradually, the proper amount of light is given to the young crop and when in three or four years the last of the mother or nurse trees are removed, a thicket of young beeches has replaced the old growth. In a similar manner, with necessary modifications in procedure according to species, climate, and soil is the natural reproduction of other species effected.

The practice of the forest manager, then, is to assist the desirable species in the struggle for existence and supremacy, to antagonize the undesirable ones, and to create proper conditions of soil, light, and composition of species for a desirable reproduction.*

The practice of thinning is based on similar principles. Regard to the danger of windfalls, of fire, of frost to the young plants, etc., will also influence the management.

So much for the technical part of forest management.

There is, as in every producing business, besides the technical part, a financial or mercantile part of the business. So in forest management we find a technique, which is based upon a thorough knowledge of natural sciences, and a mercantile part, which requires a knowledge of the factors that make such a business profitable. The technical administration and the mercantile administration must work together harmoniously, adjust and compromise their needs in order to arrive at results desirable to both.

The conditions of a proper mercantile forest management need also a brief consideration here. The absence of forest management in the United States is due to various causes, mainly arising from the state of our cultural and material development. As long as the competition of wood supplies from virgin lands, exploited for the best timber only, is to be met, forest management will be beset with great difficulties from a financial point of view. Yet it is not impossible, impracticable, untimely, or unprofitable in the location and under the conditions in which the club's property is found. A near market and facility for bringing even inferior ma-

* Reproduction from seed only is here considered, the reproduction from the stump, of which broad-leaved trees—not the conifers—are capable, may be left out of consideration at present; its desirability or undesirability on the property may be discussed at some other time.

terial to market profitably are the conditions without which forestry is financially impracticable. Accessibility, easy, cheap, and permanent means of transportation, furnish the keynote of profitable forest management.

The lumberman places only a temporary value on his property, quickly gets out the most valuable timber, taking the cream and leaving the balance, like skimmed milk, in the woods, to rot, burn, deteriorate. If nature so wills it and some cream was left in the first operation, he may return and repeat the skimming process once or twice, leaving at last an undesirable scrub-growth or "bush." The forester considers his property as a permanent investment, to produce revenue constantly and forever, in increasing rather than decreasing ratio. The factor of permanence is ever present in his methods. Like the owner of a large office building he spends part of his income from year to year to repair, improve, and enhance its value.

Here again, as in the technique, the business of the lumberman differs in methods of administration from that of the forester. The lumberman works for the present, the forester for the future. The lumberman begins his operations wherever he can get out his timber most readily; the forester has different reasons for cutting over the district in a certain order (danger from windfall, frost, fire, insects, etc.). The lumberman builds shanties, temporary roads, and waterways; the forester builds houses or at least plans them for permanent occupancy, and he plans, lays out, and builds permanent roads and other permanent means of transportation, which will enable him to utilize to the fullest extent all the product of the soil, from whatever part of his property it may appear desirable. The difficulty of doing so profitably, often, to be sure, hampers the technical management. The technical manager might see the desirability of thinning a young growth in order to bring it to a more rapid development, but not being able to dispose of the inferior material, the financial manager objects to the expenditure for the operation. The technical manager can see that in order to secure desirable reproduction, some kinds of timber should be cut first and others later, but there being no means for marketing the former, and the latter being, perhaps, floatable by the natural waterways, the financial manager insists that these be utilized first and thus the task of the technical manager may be greatly aggravated.

The demands of both technical and financial considerations constantly require adjustment. Protection of the forest against fire is a constant care both of the technical and financial manager. How to do this effectively and how to do it with the least expense is the problem. Here again a proper road system and districting of the area is an important factor, enabling the manager and his force to reach easily any part of the property that might be endangered, and secondly enabling the utilization of inferior material, which if left in the woods, increases the danger from fire.

As the aims of the technical part of forest management can be summed up in two words—natural reproduction—so can the financial policy be formulated as consisting in wise curtailment of present revenues to secure permanent and increasing revenues for the future.

* * * * * * *

For the purpose of illustrating the financial working of a forest administration, I may subjoin the following table, which exhibits the actual results of the forest administration of the Duke of Anhalt in Germany for eight years. The property consists of somewhat over 57,000 acres in all; mountainous and mostly of coniferous growth, presumably without much surplus old stock and, if the annual cut of 47 cubic feet of wood per acre—a very low average—represents the annual accretion, not of very good production. The annual cut averages in round numbers 2,675,000 cubic feet, of which 27 per cent represents lumberwood, the balance firewood; or, in round numbers, 7,000,000 feet board measure and 20,000 cords firewood. The administration is of old standing, and expenditures may be considered as current and not extraordinary; receipts other than wood refer probably to rent for meadowlands, game and fishing privileges, stones, etc. The administration cuts, but does not move the wood; prices, therefore, refer to the cut wood in the forest. Besides one forest director with three assistants and several clerks, there are fifteen district officers and forty-eight assistants and guards, the cost of the administration amounting to $30,000 annually.

Results of forest administration of the Duke of Anhalt for eight years.

[Round numbers.]

Years.	Receipts.						Expenditures.					Net profit.	
	For wood.				Other.	Total.	Wood cutting.	Roads.	Planting and other improvements.	Sundries.	Total.	Total.	Per acre.
	Total.	Per cubic foot, solid.											
		Timber.	Cordwood.	All together.									
1881	141,400	8.6	2.7	5.2	25,300	166,700	23,000	3,110	9,120	6,440	69.700	97,000	1.63
1882	137,000	8.4	2.8	5.2	28,200	165,200	21,000	2,450	9,650	5,470	67,400	97,900	1.65
1883	150,400	7.4	3.	6.	26,850	177,250	20,000	2,920	8,960	6,050	67,000	110,000	1.83
1884	153,260	8.9	2.7	5.9	26,800	180,060	20,900	2,590	9,900	5,800	68,350	111,800	1.88
1885	147,200	8.3	2.6	5.6	25,600	172,800	20,700	2,550	10,800	6,220	69,200	103,600	1.74
1886	152,500	7.9	2.4	5.3	26,750	179,250	23,950	2,630	10,000	6,570	72,200	107,170	1.79
1887	155,360	8.5	2.5	5.8	25,840	181,200	21,570	2,940	9,960	6,200	69,800	111,360	1.85
1888	161,150	9.4	2.6	5.9	25,000	186,150	22,800	3,100	9,830	7,470	74,700	111,400	1.82
Yearly average	149,780	8.5	2.7	5.6	26,290	176,000	21,740	2,786	9,660	6,275	69,700	106,300	1.78

Proportion of expenditures to gross receipts.

	Per cent.	Cents.
Wood cutting:		
Per cent of gross receipts	12.4	
Per cubic foot, solid		75
Roads:		
Per cent of gross receipts	1.6	
Per cubic foot, solid		4.[illegible]
Planting and other improvements:		
Per cent of gross receipts	5.5	
Per acre		16.[illegible]
Sundries	3.6	
Total	40	
Net profit—total	60	

From lumber wood alone the average income would be $59,500 in the woods, th cost of cutting in round numbers $5,500, leaving net income of $54,000, or over on half of the total net profit.

FOREST POLICY.

The policy of the club will have to be to find, as soon as possible, means of mar keting the hard woods. This involves laying out and gradually constructing rationally disposed, well built, permanent system of roads, the encouraging of rail road building to or through the tract, and of manufactures near to it which ca utilize the inferior material. Of the latter may be mentioned pulp mills, employin both mechanical and chemical processes (the former for utilizing the hard woods especially the beech and inferior birch), small woodenware, furniture, and carriag material manufacture, etc.

There are quite a large number of "seamy" spruce trees on the land, unfit for lum ber, which would make most excellent pulp material, in addition to the top mate rial alluded to further on.

Especially desirable is the establishment of enterprises using firewood or char coal. The club could afford to give the wood leave for smaller-sized cord wood fo almost nothing, while with cheap fuel and convenient means of transportation th manufacturer may be able to shoulder the inconvenience of using inferior mate rial and of less convenient location.

I desire here especially to call attention to the great importance which the manu

facture of pulp has acquired during the last few years. It may prove one of the most potent enemies to our forests, or else it may become the best friend of those who strive to introduce rational forest management, according to the manner in which the raw material is obtained. By using up the inferior material it may supply the one condition of profitable forest management.

Since by the present processes of manufacture the hard woods can only be used as filling material of the pulp made from coniferous woods, it should be studied how both kinds may be utilized simultaneously, in order to aid instead of impede the task of the forest manager in securing reproduction. I advise especially that you do not precipitately contract away the soft pulp woods without reference to the simultaneous utilization of the hard woods.

It may not, perhaps, be necessary for the club to do its own lumbering; this may be done under leases to lumbermen, as in the case of the spruce. In that case, however, the leases must be so formulated and executed that the object of the forest manager—proper reproduction and improvement of the property—can be attained at the same time.

To avoid complications and to make the forest management most effective, it would, however, be altogether preferable that the cutting be done on account of the club, the lumbermen to buy the logs or cord-wood cut, as it would be irksome and difficult to control the lumberman in his operations. This method of doing would have also the advantage that the men engaged in cutting and superintending the logging are under directions and may partly enlarge the permanent force of the forest administration.

The working for reproduction must be mainly directed upon the birch, maple, and spruce, except where special soil conditions and composition of the original growth demand or permit the favoring of other timbers. The detail in methods will have to be a study for the resident manager, a problem which can not be solved *ex cathedra*, but needs careful observation and consideration, and perhaps some trials first.

That the property must be guarded against fire, trespass, and improper cutting under the contract goes without saying. The cutting open of the boundary lines and proper marking of the same, with subsequent frequent revision or renewing of the marks and the districting of the property, should naturally receive early attention, as protection is facilitated by a definite knowledge of the extent and nature of the property to be protected.

FOREST FIRES.

The greatest danger against which the club has to guard is that from fire. It is miraculous almost that fire should not before have touched this tract, and this can be explained only by the comparative isolation in which the tract has been hitherto. With the opening up of the property and especially with the beginning of lumber operations, the danger increases and hence this great enemy of the forest must be anticipated.

The elaboration of regulations in regard to the use of fire on your property should engage your earliest and earnest attention. In spite of all rules and regulations and precautions against fire, it is to be expected that fires will break out, and preparations to fight the fires effectually will also have to be in the programme of your administration. I can not too strongly urge upon your committee the necessity of dealing with this subject energetically and unflinchingly at the outset. The whole fire question in the United States is one of bad habits and loose morals. There is no other reason or necessity for these frequent and recurring conflagrations. It requires only that a strong moral impression be made upon those responsible for them to reduce and ultimately remove this bugbear of American forests.

The club can afford to employ its entire income for several years solely to this object of showing its determination to break the spell and to make the appearance of fire the exception and not the rule. This can be done only by a comparatively large and well-organized force of fire guards, who will enforce the proper preventive measures and regulations rigidly and put out any fires as soon as discovered. By as much as the property is made accessible through a proper road system and convenient division into districts, by so much will the number of necessary guards and their labor be diminished.

The danger and damage from fire is increased wherever lumbering is carried on, especially from the fact that the leavings, tops of trees and limbs dry rapidly and lend intensity to any running fire. The proper disposal of these leavings should have been considered in your lumber contracts. In the absence of conditions to that affect the club must dispose of the matter on its own account. It has been urged that the leavings should be gathered and burned. This is expensive and

wasteful and it is my opinion that, at least with the spruce under the conditions before us, it is unnecessary. The danger arises from the fact that the tops braced up by the branches from the soil are dried and kept dry, like tinder. By lopping the branches and letting both branches and tops fall to the ground, it is to be anticipated that the material would be kept wet from the winter snows and soon be rotted. Besides some useful material for pulp manufacture, which the lumberman would have left, might be saved from this top material. I would at least recommend the trial of this method. The lopping should be done soon after the felling and it might be possible to make arrangements for this work with the contractor for the lumber.

* * * * * * *

ORGANIZATION.

It would be folly to undertake for the present the more refined methods of forest management practiced in Europe, or to attempt an elaborate system of organization, such as may in time become desirable. Yet, even if it were only for the purpose of properly guarding the interest of the club and its property, an organized administration must appear desirable. Such an administration would require a resident manager, three or four district officers, and a large number of permanent or temporary guards. The manager should, if possible, be a man with the knowledge of the principles of forest management as practiced abroad, yet also acquainted with the difference of conditions and methods prevailing in the United States, and, while determined and energetic, yet possessing a sufficient amount of that tact which is required to introduce new methods without unnecessarily creating antagonism and ill-will His duties would be to have the general charge of the local administration, executing the orders of your committee, assisting the members of the club in locating and constructing their camps. He will have to study, map himself in detail, and district the property and lay out the road system, supervise the construction of roads and other improvements. He should therefore be conversant with such surveying and engineering work. He will superintend the execution of the lumber cutting, make out the lumber inspector's statements for settlement, and after having familiarized himself with the prevailing forest conditions, devise in detail the plans for a proper forest management. He will be responsible for the protection of the property against fire, theft, poaching, etc., keep the force under him to its duties and attend to prosecutions of offenders in the local courts, etc. It may be difficult, though not impossible, to find a competent man of such quality and knowledge. The success of the club's enterprise must largely depend upon finding that man. I have described here only a part of the duties which are expected of the district officers in French and German forest administrations. To such a man the club can afford to pay a good salary.

The district officers should be reliable men, with some knowledge of woodcraft, and capable of acting on their own responsibility. They should be stationed each one in a different district, for which he will be held responsible. During the lumbering season they will be mainly engaged in watching the lumber operations and surveying lumber cut under contract or otherwise. Those not so engaged will assist the manager in the survey and locating of roads, etc., or they will superintend directly the work on roads, improvements, or other operations. In summer time and during the hunting and fishing season they will be especially charged, with the aid of the guards, to watch for fires and trespassers, and their energies should be entirely devoted to the duty of protection.

The permanent force of guards need not be large, only as many as could be profitably employed in the works of improvement going on during the off season, when danger from fire or poaching is passed. One assistant to each of the three or four district officers and to the manager might suffice. These officers as well as the guards must be under the direct orders of the local manager.

I have pointed out that this permanent force could be larger, if the club does its own timber cutting, the foremen of the lumber camp becoming guards during the hunting season. Otherwise this force may have to be increased temporarily during the time of need, say for the months of June to October. But the protective efficiency could be greatly enhanced without much, if any, additional cost by having only licensed guides on the property and by charging these guides, who are necessarily all the time going through the woods, with the right and duty to enforce the regulations of fire and game laws.

In order to make this force still further effective, all the officers and guides should be clothed, if that be attainable, with sheriff's power for the enforcement of the State game, fire, and trespass laws. It is the present circumlocutory manner of applying the law and absence of proper police force which make the State laws largely nugatory. Responsible people, with a permanent interest in the property they are to

guard, clothed with the power to apprehend and bring to jail any offenders, will soon make that moral impression which is necessary to change present malpractices.

The permanent officers should live on the property and be so located as to guard especially the entrances to it most effectively. The cost of an efficient service like the one described I estimate in round figures at $8,000 for the permanent force, the lodges for officers to be furnished by the club. For the first few years as liberal a curtailment of the income as possible should be suffered by the club for improvements, especially roads. The value of the property will rise in excessive proportion to the expenditures made in rendering it accessible.

* * * * * * *

In fact, as soon as the service is satisfactorily organized and the preliminary work of mapping and the location of a rational road system determined upon, the work of developing it should be pursued with all energy up to a certain point, afterward more gradually; for, as I have tried to impress upon you in the foregoing, proper and profitable forest management is dependent upon the possibility of marketing inferior material, and this is possible only with permanent and easy means of transportation.

* * * * * * *

I have dwelt at length on some elementary considerations, because with the present movement in the State of New York to establish in the Adirondack region an extensive State park it is desirable that the members of your club should be fully imbued with proper conceptions as to what is or ought to be involved in such a proposition. The State of New York has hitherto been incapable of grappling with the question of forest preservation in the Adirondacks solely because of ignorance as to what forestry and forest conservation involve, and, secondly, because the question was not treated as a business proposition. The club will fail in the same way, as far as forest management and forest conservation are concerned, unless it is placed upon a business basis.

The great State of New York, with 3,000,000 or 4,000,000 acres of woodlands reserved as a State park as proposed, ought to be able with such a park not only to protect its watersheds and to furnish hunting, fishing, and health resorts to its citizens, rich and poor, but with only half the area productive and large amounts spent for improvements and recuperation of burnt areas such a forest property should not only pay its maintenance expenses and interest on purchase money, but by and by return to the treasury and relieve of taxation its citizens to the amount of several million dollars.

FORESTRY EDUCATION.

The difficulty of introducing proper forest management into the United States, aside from that inherent in the economic development of the country in general, as pointed out in the foregoing pages, may be assigned to the absence of competent managers. The demand for such will presently arise, and it will be difficult to meet it. It is questionable whether forestry can be studied in this country to advantage as long as it is nowhere practiced, and hence practical illustration is lacking. On the other hand it is doubtful whether foresters can be imported from abroad capable of adjusting their methods to the different conditions existing in this country. It seems best, therefore, that young men with suitable preliminary preparation should go abroad to acquaint themselves, partly at the forest academies and partly by practical work in the woods, with the theory and practice of forest management. A sojourn of from one to two years abroad should suffice for anyone equipped with the necessary botanical and technical preparatory education.

For the purpose of ascertaining the present educational facilities existing in this country, letters of inquiry have been addressed to the various agricultural colleges and experiment stations. Leaving out negative replies, the following abstracts from letters received from professors of horticulture and botany show the extent of these facilities.

Students coming from these courses and wishing to prepare themselves to become forest managers, may find it advantageous, before

taking a course abroad, to avail themselves of the facilities of this Division, now quite considerable, for the purpose of acquainting themselves with the literature, classic and current, and with the theories upon which forest management is practiced abroad.

VERMONT.—*State Agricultural Experiment Station;* W. W. Cooke, director: Forestry is incidentally touched upon in our course on physiography. Special attention is given to influence on rainfall and climatology. All students in agricultural course take physiography (Tyndall's work) in spring term of freshman year.

RHODE ISLAND.—*State Agricultural School:* Prof. L. F. Kinney will teach forestry two hours a week in the spring term, and discuss in lectures the propagation of forest trees, methods of planting, effect of forests on climate, etc. All students take this course. Present class, 30.

MASSACHUSETTS.—*Agricultural College;* Prof. S. T. Maynard: Forestry taught twelve weeks in junior year by lectures and text-books. Thorough botanical study of American forest trees. In horticultural lectures propagation of fruit and ornamental trees, special methods in nursery, transplanting, and arranging in forest plantations, time of cutting timber, seasoning, etc.; quality of wood and timber of common timber trees, study of condition of forests, especially in New England, importance of their preservation, influence on climate, rainfall, droughts, etc. *Bussey Institution of Harvard University;* Prof. B. M. Watson: Give thirty-six lectures on trees and shrubs, in addition to regular course on horticultural practice, bearing chiefly on ornamental planting. Instruction on methods of propagating and planting, care of nurseries, and method of treatment to bring existing plantations into good condition and to maintain them so.

NEW YORK.—*Cornell University, College of Agriculture;* Prof. A. N. Prentiss: Lecture on arboriculture once a week during the year, with collateral reading and some field and laboratory work on native trees. Some lectures on forestry in Europe and on forestry and forest problems in the United States. Study wholly elective and attended by fourteen students.

PENNSYLVANIA—*State College;* Prof. W. A. Buckhout: Lectures on forestry. Endeavors to present the subject in all its parts.

TEXAS.—*State Agricultural College, horticultural department;* Prof. S. A. Beach: Forestry is given in the senior year of the courses of agriculture and horticulture, during the fall term. Two recitations and one "practice" per week. Practice with compound microscope on structure of leaf and wood. Identification of trees. No strictly forestry course.

MICHIGAN.—*Agricultural College;* Prof. J. W. Beal: Forestry elective in senior year. Daily study twelve weeks. Lectures. Excursion to arboretum and woods. Study of the most prominent species of the neighborhood, physiology and growth, classification, something of distribution, management of forests here and in Europe. Timber, structure, and uses. About half the senior class, if any, elect forestry, say fifteen to twenty.

MINNESOTA.—*University, College of Agriculture;* Prof. S. B. Green: Give all instruction in winter, so can not demonstrate some points as I would like to do. Lectures, in connection with Hough's Elements of Forestry as text-book, and collection of plants on University grounds. Special attention to climatic effects of forests. Economic value, shelter belts, desirable species to plant, and methods of planting, identification of species. All graduates required to take the course and it is very popular.

MISSOURI.—*Agricultural College and Experiment Station;* Prof. J. W. Clark: Instruction by lectures and practical work in the nurseries. Use, durability, rapidity of growth, adaptation, modes of propagation and cultivation, diseases, insect enemies. About eight students take the course.

NORTH DAKOTA.—*Agricultural College:* College lately established. Catalogue shows contemplated lectures (six) on forestal subjects.

SOUTH DAKOTA.—*Agricultural College;* Prof. C. A. Keffer: Forestry taught by lectures and assigned reading. Students required to take field notes on characteristics, rates of growth, methods of culture, etc. Excursions to natural woodlands and plantations. Influence of forests on climate, wind-breaks, characteristics of trees suitable to South Dakota. All junior class take forestry. Ten students this year. Forty students worked on the forest plantation.

KANSAS.—*State Agricultural College:* Prof. E. A. Popenoe: Instruction in forestry given only so far as relates to propagation and management of trees for wind-breaks and ornamental planting. Instruction to all students of the second year. Plantation of 20 acres of forest trees on college grounds, set both in pure blocks and mixed. Thousands of trees experimentally propagated annually. This work and the care of plantations in the hands of students almost exclusively.

ILLINOIS.—*University of Illinois, College of Agriculture;* Prof. T. J. Burrill: Seven weeks optional instruction on forestry to senior class. Few, sometimes none, take it. In the regular course, forestry touched upon under botany and landscape gardening. Species identified in the woods and the laboratory, and characteristics studied, with some lectures on geographical distribution. Trees for ornament and shelter studied in ten lectures, with illustrations on the grounds. From ten to twenty students in this required course.

OREGON.—*Agricultural College, Experiment Station;* Prof. E. R. Lake: Forestry elective in fourth year. Institution only three years old. In second year students in the mechanical course have a course on "wood structure." Use Ward on "Timber and its Diseases," with lectures.

UTAH.—*Agricultural Experiment Station;* Prof. E. S. Richman: Nothing done yet. No class yet for second year. In the future I will make forestry a special feature, chiefly with reference to propagation and cultivation of trees valuable for lumber.

COLORADO.—*Agricultural College, Experiment Station;* Prof. C. S. Crandall: No special course in forestry, but in connection with horticulture; lectures on gathering, preservation, and sowing of forest-tree seeds, treatment of young seedlings, and best methods of culture, especially of species adapted to this region. Art of transplanting and use of trees for ornament, shelter belts, etc. Ten students in last class.

CALIFORNIA.—*University of California; Experiment Station*; E. W. Hilgard, director: Forestry taught only incidentally, as connected with the subject of economic botany.

STATISTICS OF EXPORTS AND IMPORTS OF WOOD AND WOOD PRODUCTS.

As has been customary hitherto the statistics of forest products as extracted from the report of the Bureau of Statistics is exhibited in the subjoined tables, in comparison with the figures returned for the year 1880, from which we learn that our exports have grown in value by about 75 per cent during that period, while imports have advanced only 50 per cent. It will be observed that the increase in exports is greatest in the crude material.

Exports of wood and wood products, 1880 *and* 1890.

Articles.	1880.		1890.	
	Cubic feet.	Value.	Cubic feet.	Value.
Firewood	387,600	$11,552	978,944	$16,746
Boards, deals, and planks } Joists and scantling }	23,767,000	4,223,259	51,067,833	9,974,888
			2,223,666	381,640
Hoops and hoop poles	5,339,800	427,187	749,725	59,978
Laths } Palings, pickets, and bed slats }	79,575	11,936	167,856	24,951
			238,480	30,653
Shingles	760,354	165,893	511,378	111,926
Shooks:				
Box	544,328	136,082	474,228	118,557
Other } Staves and headings }	35,109,760	3,510,976	2,299,821	766,607
			37,152,855	2,476,857
All other lumber	6,379,590	765,550	11,292,842	1,355,141
Timber:				
Sawed } Hewed }	16,365,346	2,219,320	22,582,000	3,384,847
			8,732,761	1,381,747
Logs and other timber	9,874,100	789,927	21,004,325	1,680,346
Total unmanufactured	98,607,455	12,261,682	159,476,714	21,764,884
Manufactures of—				
Doors, sash, and blinds*	....	....	427,787	320,840
Moldings, trimmings, etc	....	....	155,060	116,295
Hogsheads and barrels, empty	349,372	262,029	567,037	425,278
Household furniture	2,205,171	1,653,878	4,118,506	3,088,902
Wooden ware	441,516	331,137	480,687	360,515
All other manufactures	2,304,867	1,728,650	2,930,420	2,197,815
Total manufactures	5,300,926	3,975,694	8,679,497	6,509,645

* Until 1884 the exports of doors, sash, blinds, moldings, etc., are included by the Bureau of Statistics in "all other manufactures," and can not be given separately. For the same reason the reports of some other articles can not be given separately for every year.

Exports of wood and wood products, 1880 *and* 1890—Continued.

Articles.	1880.		1890.	
	Cubic feet.	Value.	Cubic feet.	Value.
Naval stores:				
Rosin				$2,762,373
Tar		$2,452,908		56,105
Turpentine and pitch				35,037
Spirits of turpentine		2,132,154		4,590,931
Total naval stores and spirits of turpentine		4,585,062		7,444,446
Ashes		110,578		26,211
Bark and tanning extracts		210,126		263,754
Ginseng		533,042		605,233
Matches	39,749	119,246	20,761	62,284
Agricultural implements ....number	28,205	2,245,742		3,859,184
Sewing machines	65,975	1,649,367	111,751	2,793,780
Musical instruments		811,177		1,105,134
Carriages and steam and horse cars		1,407,425		4,746,678
Total miscellaneous	105,724	7,086,703	132,512	13,462,258
Total exports	104,014,105	27,909,141	168,288,723	49,181,233

Imports of wood and wood products, 1880 *and* 1890.

Articles.	1880.		1890.	
	Cubic feet.	Value.	Cubic feet.	Value.
Free of duty.				
Wood, unmanufactured, not elsewhere specified:				
Firewood	13,182,816	$266,044	19,669,376	$320,882
Logs and round timber	4,373,400	349,872	11,812,775	945,022
Railroad ties	3,565,983	213,959	6,684,177	444,513
Shingle and stave bolts	1,057,025	84,562	1,360,687	108,855
Ship timber	172,980	43,245	363,724	90,931
Ship planking	107,691	35,897	104,991	34,997
Wood pulp		5,740		100,443
Hemlock bark		476,149		163,673
Dutiable.				
Wood, unmanufactured, not elsewhere specified	154,024	19,253	89,352	11,169
Timber	49,854	6,222	*84,960	10,620
Lumber:				
Boards, planks, deals, etc.	39,542,864	4,763,441	48,334,000	6,724,716
Clapboards	727,333	19,759	1,636,000	75,672
Hubs, posts, lasts, and rough blocks	555,328	99,959	268,583	48,345
Laths	2,079,344	110,505	4,936,720	361,375
Pickets and palings	379,040	31,846	652,880	38,897
Shingles	823,788	116,608	2,728,894	414,921
Shooks and packing boxes	316,128	79,032	603,668	150,917
Staves	13,243	4,729	1,591,071	427,998
Bark extracts, chiefly hemlock		22,863		†481
Sumac		588,911		376,784
Cork and cork bark, unmanufactured		104,808		222,933
Matches	4,959	14,879	14,686	44,059
Manufactures:				
Casks and barrels		3,517		632
Cabinet ware and furniture		147,783		414,780
Osiers and willows, peeled and dried	1,209,945	21,833	1,909,381	27,646
Osier and willow baskets		142,214		372,356
All other manufactures		592,112		516,622
Free of duty.				
Cabinet woods:				
Box		27,563		36,712
Cedar		465,169		472,478
Ebony		84,354		47,794
Granadilla		5,050		2,322
Lancewood		14,655		8,993
Lignum-vitae		28,343		45,967
Mahogany		266,026		624,719
Rose		178,578		38,959
Sandal		3,400		102
All other cabinet woods		306,354		249,108
Cork wood or bark, unmanufactured		658,830		1,213,876
Total	68,520,349	10,403,044	[illegible],845,925	15,291,269

* Quantity not all stated.

† Hemlock only.

ARTIFICIAL RAINFALL.

By an amendment in the Senate the appropriations for this Division were increased by the sum of $2,000 and the words "for experiments in the production of rain" were added to the reading of work to be performed under the appropriations.

At first sight, the reference to this Division of such experiments would appear to have been made by reason of the claimed influence of forest areas upon the distribution of rainfall. It was, however, learned that these experiments were not intended to have such a connection nor were they to be devised for the purpose of finding out any special means for the production of rainfall, but they were to be carried on upon the assumption that explosions would have the desired effect and the money was appropriated to be expended in the purchase of explosives and in their discharge.

With such a programme the reference was, to be sure, unfortunate, for aside from the fact that neither the Division nor the Department in any of its branches commands the means or the men to conduct such explosions or the instruments which should at least be observed during the explosions in order to arrive at an understanding of the results, should any be attained, the amount appropriated in the absence of such means and persons is so totally out of proportion to the needs of the experiment, and, indeed, to the expected overawing result of controlling nature's most potent and hidden forces, that an attempt to use it in the proposed manner could hardly fail to be barren of results.

On the other hand, the War Department commands cannon, explosives, and men trained and accustomed to handle them, and in its Signal Service, instruments for meteorological observations and observers, and as long as the experiments are to be carried on upon the assumption that explosives will be effective, I have submitted the propriety of asking the coöperation of the War Department in this matter. I have also submitted, as my opinion, that the assumption for such experiments is, to say the least, hazardous, and that a much better use of the money could be made and valuable results much more likely attained, by devoting it to a series of experiments, which would bring us first nearer to a conception of what forces are at work in producing rain and to learning more about the chances of substituting feeble human efforts for grand cosmical causes.

The theories in regard to the causes of storms, and especially their local and temporal distribution, are still incomplete and unsatisfactory. It can by no means be claimed that we know all the causes, much less their precise action in precipitating moisture. It would, therefore, be presumptuous to deny any possible effects of explosions; but so far as we now understand the forces and methods of nature in precipitating rain, there seems to be no reasonable ground for the expectation that they will be effective. Hence, while I do not believe, contrary opinions of high authorities notwithstanding, that such experiments are necessarily devoid of merit, as long as they are conducted upon a careful, scientific plan and a large enough scale, it would be unreasonable and contrary to the spirit of our advanced civilization to rush into a trial which does not seem warranted by our present knowledge, instead of starting with a series of carefully devised experiments, the first object of which would be to learn something of the effects of explosions upon the atmosphere, a knowl-

edge which we do not possess and which, if not leading to the power of controlling rainfall, may considerably advance our knowledge of meteorological forces.

It sounds quite simple to try whether explosions will produce the precipitation, but when it comes to practically arranging the trial, such questions as the following it seems must be settled first: What kind of explosive shall be used? Is it intensity or frequency of explosions that should be tried? What amount should be used? What means of exploding are best adapted to the purpose and in what manner should they be employed; how high above ground would the explosions be effective? Lastly, how shall we know whether precipitation was due to the explosions? How far did other conditions influence precipitation, etc.? These are questions which it would puzzle experts to answer on any basis of present knowledge.

A large number of trials, with all sorts of differences in the conditions, might possibly settle some questions, but, unless careful observations, not easily devised, were made simultaneously as to the effects upon primary conditions, under which the result is obtained, our trials would lead us no further than we are at present, namely, to the very unsatisfactory assumption upon which we based our trials.

Under these circumstances, up to the present writing no attempt has been made to advance this problem.

Meanwhile I have tried to trace the history and scan the evidence which has led to the assumption that explosions will produce precipitation, and incidentally I have also inquired into other means of artificial production of rain which have been proposed.

It is no wonder, in view of the important office which the absence or presence of rainfall plays in the economy of man, that the desire to control it is as old as history, and various attempts to do so have been made or proposed in all parts of the world. The resort to prayer for the purpose is well known. In India the rainmaker, called *Gapogari*, is an important personage and similar professional rainmakers are found among African tribes and among the Indians. These, to be sure, have their secret methods, with which our knowledge of natural forces could hardly harmonize.

In more recent times two artificial causes of rainfall have exercised the minds of speculative meteorologists, fire and explosions.

It is a current belief that large fires and the cannonading during battles cause precipitation.

Singularly enough the belief that battles occasion rain is older than the invention of gunpowder. Thus we read in Plutarch: "It is a matter of current observation that extraordinary rains pretty generally fall after great battles;" and he explains it, that either some divine power in this way cleanses the polluted earth or that moist and heavy vapors steam forth from the blood and thicken the air, and make the moisture fall.

It should also be borne in mind by those who believe in the effectiveness of cannonades in bringing on storms, that according to Arago ("Thunderstorms," pages 164–165) during the latter part of last century, and as late as 1810, it was a popular practice in the communities of Southern France to fire off batteries, especially kept for the purpose, in order to *dispel* violent rain and hail storms, which were undesirable visitors of the region. Arago traced the history of this belief to a naval officer in that region, who had propagated the practice of navigators of that time of dispelling waterspouts and thunder

clouds by that means. Before this innovation the effect was sought by the ringing of church bells. Arago tried to disprove such an effect and to prove the opposite by showing that during the artillery practice at Vincennes, out of 662 days each preceding, following and during the practice, there were cloudy 128, 146 and 158 days respectively. This seems to be a rather small percentage to establish the positive effect he claimed; however, it may prove the futility of the opposite belief.

Napoleon has been credited with making use of the experience, that battles produce rain, in the disposal and manœuvering of his troops, and the belief in cannonade and rainfall as cause and effect has since become quite current.

The most elaborate effort to obtain evidence on this point is that of Mr. Edward Powers in his book, "War and the Weather, or the Artificial Production of Rain," published in 1871, when the extraordinarily wet seasons concomitant with the war movements in France brought the subject into prominence.

Although the writer himself, who took part in the campaign and well remembers the inclemency of the season, can not recall a single instance when engagements were followed by rain that would not have been anticipated from the general conditions of the atmosphere, yet he will not deny that the evidence collected by Mr. Powers from the Mexican war and that of the rebellion, with a few other additions, appears at first sight cumulative and overwhelming. In many cases, however, even the very imperfect records allow an explanation of the rainfall as due to natural conditions without effect of the cannonading, and it may well be asked whether as many, and even more, records could not be gathered of battles which were not followed by rain. Most of the evidence is drawn from recollections with which I find other recollections at variance, and since altogether general meteorological data for the period from which these records are drawn are lacking, the evidence after all falls considerably below the standard of positive proof. The negative proposition only is proved, that not all battles are unaccompanied by rain, as not all dreams fail of realization. In the accumulation of such evidence the danger is lest we indulge too readily in the "*post hoc ergo propter hoc*" argument. It would have to be shown that there were no well-understood natural reasons present for the occurrence of,precipitation. In fact a few careful correspondents of Mr. Powers point out that such reasons often existed. The position taken by Maj. Gen. Thomas I. Wood, in his letter to the author, seems to be the proper one. He says:

> Many battles have been followed by rain while others have not. This fact would seem to indicate that if the atmospheric disturbances caused by the firing in battle have any effect in producing rain, the actual accomplishment of rain depends, in a general manner, if not chiefly, on the condition of the atmosphere. The condition of the atmosphere should, hence, be one of the chief factors to be observed in the experiments you propose.

The only actual experiment that has come to the writer's notice in which a cannonade seems to have been directly effective was reported a short time ago in La Nature and is vouched for by a M. Guillaume. A French artillery division moved out for a sham battle; when ready for action a dense mist arose, which obscured the entire valley so that one could not see 300 feet. One of the officers, recalling the asserted influence of cannonades, proposed to try the remedy; four mortars fired 1-pound charges, first eight shots in suc-

cession, then two salvos of four each, when suddenly the mist disappeared, clearing the valley for 3 miles and a fine drizzling rain fell, which, as the cannonading of the sham battle continued, did not cease all day, sometimes falling in heavy showers. I have not been able to ascertain the authenticity of this report and the general weather conditions prevailing at the place and time.

Our present meteorological knowledge does not give much hope for success by this method of rain production. A method which appeared more reasonable, or at least one that seemed to be in agreement with our present theories of storm formation, was proposed by the author of these very theories.

The belief in fires and rain as cause and effect is also a very old one, but it was Espy who first, in 1839 (having shown that a column of air rising to a height where, owing to diminished pressure, it would expand, was by this expansion cooled, thereby condensing and eventually precipitating its vapor), proposed experiments "to see whether rain may be produced in time of drought, making a large body of air ascend in column by heating it."

Besides his general theories, which were accepted as most reasonable explanations of the formation of storms, he brought forward evidence to show that volcanic eruptions and large fires (he also refers to the cannonade of battles evidently as producing heat) were followed by rainfall.

The evidence is of the same kind as that brought to show the effect of cannonades. The negative cases, where conflagrations failed to produce rain would probably be found as numerous as the positive ones. In almost all those which allowed an analysis of atmospheric conditions, these were favorable to cloud formation, namely, a high dew-point and a calm and sultry air, which Espy admitted were needful conditions and which, at least the former, are rarely present in times of drought. The great fires of London and Chicago are cases in point. In forty-two large fires and two serious explosions, occurring in Australia, during twenty-one years, "there was not one instance in which rain has followed within forty-eight hours as an evident consequence of the fire."

It will again be interesting here to note that Volta, the great physicist, proposed to use fire for the very opposite effect, namely, to dispel thunder clouds.

The impracticability of this method was exposed by Mr. H. C. Russell, government astronomer at New South Wales, who showed that in order to increase by 60 per cent the rainfall at Sydney, where the average humidity is 73, and wind velocity 11 miles per hour, at least 9,000,000 tons of coal would have to be burnt daily, since it would be necessary to raise a column of air over a surface of at least 10 miles by 1,000 feet to a height of 1,800 feet; and while there may be found some flaws in his calculation, it gives an approximate idea of what forces are to be dealt with and of their enormity.

Mr. Russell, who was then (in 1884) antagonizing the idea of inducing the Australian Government to engage in experiments like those now proposed here, concludes:

> It would seem unreasonable to hope for the economical production of rain under ordinary circumstances, and our only chance would be to take advantage of a time when the atmosphere is in the condition called unstable equilibrium or when a cold current overlies a warm one. If, under these conditions, we could set the warm current moving upwards and once flowing into the cold one, a considerable quantity of rain might fall; but this favorable condition seldom exists in nature.

Professor Henry, one of our most enlightened and unprejudiced physicists, expresses himself as follows in regard to Espy's propositions:

I have great respect for Mr. Espy's scientific character, notwithstanding his aberration in a practical point of view as to the economical production of rain. The fact has been abundantly proved by observation that a large fire sometimes produces* an overturn in the unstable equilibrium of the atmosphere and gives rise to the beginning of violent storms.

To understand how precipitation may possibly be effected by artificial means, it is necessary to know how it occurs in nature. First we must have a source of moisture, and then conditions which will cause the condensation and precipitation of that moisture.

Besides the moisture carried into the atmosphere by its direct evaporation from the soil and minor water surfaces in the locality under consideration, there is an amount, and in most cases probably the largest amount, brought by currents from such large water surfaces as the seas. It may be taken for granted that the evaporation from the great oceans furnishes the largest amount of the water of the atmosphere.

To conceive the conditions under which the air is likely to give up this water held in suspension, it is necessary to know first that air can hold suspended an amount of vapor proportioned only to its temperature. If the temperature be lowered by any means the vapor will be condensed, while an increase of temperature permits a further increase of vapor. In order, then, to produce condensation, it is necessary either to cool the air to or beyond the point (dew-point) where it can no longer hold the vapor, or to add to its moisture as much or more than it can hold at its present temperature.

The next thing to know is that the air, being heated by contact with the earth, which receives its warmth from the sun, is warmest near the ground and cooler farther away from its source of heat; and warm air being lighter than cold it rises, being displaced by the cold air which sinks and takes its place to be warmed and to rise, so that there is a constant circulation of air currents established. At the same time by evaporation moisture is added to the air in contact with the surface of the ground, and vapor being lighter than air the upward movement is thereby assisted.

The third factor of importance is that air in ascending cools, because by moving into regions of less pressure (the column of air compressing it being less as it ascends) it expands, and in doing so renders a certain amount of its heat latent, namely, the amount which is necessary to do the work of expanding, hence the sensible temperature of the air is reduced, and in consequence, as we have seen, its capacity to hold moisture, and hence it is brought nearer to condensation. The exact reverse is the case in descending air, namely, as it is compressed under the increasing amount of air above it, some of its latent heat becomes sensible heat; it becomes warmer and capable of holding more water, and hence is less liable to condense its vapor. The general rain conditions of any locality depend upon its position with reference to the air currents coming from sources of moisture and especially the elevations intervening.

The cooling of the upper air strata and the condensation of the moisture which they carry, mainly derived from the great sources of water, the seas, is assumed to take place by ascending air currents.

*Should perhaps read, "is accompanied by."

The ultimate causes of these ascending currents are stated by Prof. Cleveland Abbe in Appendix 15 of the Annual Report of the Chief Signal Officer for 1889, in which he also discusses in detail all the forces now known to be at work in storm formation, as follows:

(*a*) Very local heating of, and evaporation into, the lower stratum and resulting steep vertical currents or interchange of air, due to differences of buoyancy produced by the heat and the moisture, and which differences continue to exist in the ascending mass, relative to its surroundings, until the heat is lost by radiation and the moisture by precipitation.

(*b*) Very widespread differences of temperature, such as that between arctic and equatorial regions, plateaus and lowlands, oceans and continents, the dark half and the illuminated half of the earth, these produce a nearly horizontal flow of air underrunning and uplifting the lighter air.

(*c*) The advent of the horizontal flow into a region where the coefficient of horizontal resistance on the earth's surface is increased, such as the flow from the smooth ocean to the land surface, or from horizontal smooth prairie to hilly country.

(*d*) The forcible pushing up over hills and plateaus and mountain ridges of air that would have moved horizontally toward a region of low pressure were the ground horizontal. Such cases occur systematically when a region of low pressure advances toward a mountain range.

(*e*) An updraft from the lower stratum is caused when the air immediately above it becomes abnormally buoyant, either by the sudden formation of cloud, rain, and evolution of heat, or by the warming effect of the sun on the cloud.

(*f*) An important irregular movement takes place when the air passes over hilly countries, due to the fact that the horizontal current impinging against the side of a hill is by its inertia driven upwards; it soon descends again and strikes other hills, and thus any given isobaric or isostatic surface has an undulation similar to the standing waves in a shallow stream flowing over a rocky bed. The interference of these uprising downflowing currents with the ground and with each other causes a loss of horizontal velocity, a thickening of the depth of the horizontal flow, a slight increase of static pressure.

(*g*) The local heatings and evaporation mentioned in paragraph (*a*) are most active during sunshine and sensibly zero at night time. These produce in the daytime uprising and conflicting currents and an increase of pressure.

With the fact before us that the ascending current is cooled and thereby condenses its vapor, we explain the aridity of the interior basins and the plains. The Pacific Ocean is the source of moisture, which is carried landward by the west winds. As these strike the coast range and again the mountain ranges of the Sierra Nevada they are forced to ascend, expand, and cool, and drop part of their moisture. Descending on the other side, they arrive not only much drier, but by compression much warmer. Not finding any additional source of moisture to enrich themselves from, except the scant evaporation from the ground, they pass over the interior basin and are made to ascend again the Rocky Mountain range, and that several thousand feet higher than before. Again they are drained and again they descend as warm and dry winds; hence the low relative humidity, deficient rainfall, and high evaporative power of the winds in the plains. Incidentally, I point out again here how under these circumstances the forest cover on the eastern slopes of these mountain ranges is of so much greater importance than on the western slopes, as it is likely to aid in recuperating to some extent the moisture conditions of the descending current, while with the removal of the protecting soil-cover its drying effects would be aggravated.

The amount of atmospheric moisture, then, in these regions which are, I suppose, to be mainly benefited by artificial rain production, for the reasons stated is exceedingly scanty, their mean relative humidity being below 45° during the months of vegetation. In order to bring air in such conditions to condense its vapor there must be

either a considerable addition of moisture or a very considerable amount of cooling effected, for which artificial means seem entirely inadequate.

There occur, however, times when the cloud formation would indicate that a considerable amount of moisture is suspended near the point of condensation, yet no precipitation takes place, probably on account of a stable equilibrium of air masses over large areas. It is at such times that there is more hope for influencing condensation and the timely or local discharge of the clouds.

But, if our present philosophy of the causes that produce condensation is correct, it can hardly be conceived how explosions can produce the ascending current necessary to effect the cooling of the upper strata. It must not be overlooked that the effect is to be produced through heights of more than 1,000 to 2,000 feet, and the disturbance of the stable equilibrium must encompass a considerable air column. While in such cases the possibility of results from mechanical disturbances like explosions may not be doubted, the use of these means for practical purposes remains extremely doubtful in consequence of the amount of explosive material which it would be necessary to use in order to produce results. Neither the disruption and violent agitation of the air, nor the thermal changes, nor the smoke produced by ordinary explosions would appear, either singly or combined, of sufficient magnitude to change conditions, as we have only lately learned during the explosion of the Dupont Powder Works, when 100 tons of powder exploded in eight seconds without producing an effect upon weather conditions.

We are then brought to the conclusion that unless other forces than these mechanical ones, and other movements than these mass movements, play a role in rain production and can be originated or set in motion by human device, we may as well abandon the attempt.

To the meteorologist, who, with the opportunity of watching the daily weather maps, the path and progress of the great storm centers eternally moving around the earth, probably often without disintegration, like the eternal motion of the earth itself, is brought face to face with the great cosmic causes of storm formation, who knows that an area of not less than 400,000 to 500,000 square miles must be under the influence of barometric depression to the amount of say half an inch before the storm discharges, the attempt to influence this grand natural phenomenon by the explosion of a few thousand pounds of powder or a fire of practicable dimensions appears indeed puerile.

Relying upon the working theories now accepted as explanatory of storm formation, he can calculate the omnipotent immensity of forces at work, against which limited human efforts seem utterly hopeless. This very year, almost as I am writing, Professor Hann, of Vienna, the highest living authority in meteorological science, has I believe definitely proved what has been long contended that our storms are only partial phases of the general circulation of the air, and even the variation in terrestrial surface conditions, the heating and cooling of continents and seas as well as the local influx of water vapor and its condensation are only of secondary importance, while we had hitherto considered them the causes of storms, barometric differences, etc. He admits that they may strengthen or destroy the ascending or descending eddies and modify their paths and their rate of progress, but insists that they can not act as primary causes. Other meteorologists, with questionable show of good phi-

losophy, ascribe the storm-producing air currents to magnetic forces of the earth, and the eddies and storms as a result of a readjustment of these forces.

And yet, while we may admit that the great storm movements are due to cosmic causes, we must not overlook that within their path there are minor terrestrial influences, sometimes not of entirely uncontrollable magnitude, which seem to influence within certain limits the localization of storms and the temporal distribution. We claim this influence for instance for forest areas, water surfaces, etc.

Altogether the theories for storm formation, while perhaps sufficient to explain the general philosophy, do not seem capable of explaining satisfactorily the smaller modifications and side shows, as we may call the exhibition of local showers, thunderstorms, and squalls. Nor can it be said that the detail of the manner in which the vapor condenses and the rain drop is formed, or in fact the forces active or conditions necessary in this condensation are fully known or understood. Who could, for instance, account for the fact that the dew-point may be at and above 100 without precipitation occurring? We know some seemingly necessary conditions, but we do not know all. For want of experimental knowledge meteorology seems to have lagged behind the times.

While the mass movements that are calculated to satisfy the existing theories of general storm formation may be necessary for such formation, is it altogether inconceivable or unphilosophical to think that other, molecular, forces may participate and in fact be a condition *sine qua non* in forming precipitation? Is it not also conceivable that, as in many chemical reactions, it is only necessary to give the impetus to molecular motion, to initiate the change, metabolism, which, being induced at some center of formation, spreads and assumes greater and greater proportions, similar processes may take place in the condensation of vapor from the air? If such were the case the expectation of at least a partial control by human agency might well be realized. Suggestions of this kind have been made before, not only by those who would suggest any forces to explain phenomena without understanding the possibilities of such forces to do the work, but by physicists upon experimental basis.

Laboratory experiments by Mr. Aiton seem to indicate the presence of dust particles as an essential condition for rain production; and, although Professor Abbe "dismisses from consideration at present" the influence of atmospheric electricity in storm production, he does so only because we know too little about it, and because an assumption of such influence does not seem to help the accepted theories of air movements as sole causes. Even so, he is compelled to admit that "actual measurements of electrical potential would seem to show that two masses of air in extreme conditions may attract or repel each other electrically to an extent sufficient to produce appreciable phenomena of motion even in comparison with the far more important motions produced by solar heat and terrestrial gravity."

That the air is generally negatively electric during rain storms was first established from over ten thousand observations by Herschel. Lord Rayleigh showed experimentally that moderately electrified water drops tend to coalesce, but that strongly electrified drops repel one another, from which we may infer a real causal connection between rain and electrical manifestations; and after all, even though the ascensional current may be the primary cause for cloud formation, electric conditions may determine the precipitation.

We have hitherto been told that the electrical discharges during thunderstorms are the sequel and not the cause of the condensation; but this is by no means proved. Nor is the following explanation of any assumed effect, given by Professor Abbe, the only possible one:

Even if we allow that the condensation of smaller cloud particles into large rain drops and their consequent fall to the ground depends upon the electrical discharge, yet this assumption if adopted will merely modify our mechanical views somewhat, as follows: The latent heat evolved in condensation must be considered as not wholly consumed in directly warming the air, but as partially employed in maintaining a state of electrical disturbance or tension, which latter comes to an end as soon as the flash or the silent discharge of electricity occurs. At this moment, therefore, on the one hand larger drops are formed and fall to the ground, and on the other hand the energy that had been potentially present in the electric phenomena now becomes heat and warms and expands the air. Thus the electric tension and its concluding flash have merely served to delay the communication to the air of the heat that was a few minutes before present in the vapor.

It was Sir William Thompson who first suggested that changes of weather might be foretold by the change from positive to negative electricity of the air or the reverse, and who devised the instruments for such observations in the electrometer and "water dropper." Unfortunately when, some few years ago, the U. S. Signal Service undertook some experiments in that line, under the direction of Prof. T. C. Mendenhall, this object of weather prediction was kept in the foreground, and the experiments, which form the basis of a voluminous report still unpublished, were only too soon abandoned because they did not yield readily results for the purpose in view. I am assured by the gentleman who was in charge of these investigations that, if carried on without this immediate object in view, they would undoubtedly have led to a better understanding of atmospheric conditions, and are worthy of further pursuit.

In conclusion I may refer to the observation that dust particles are found always charged with positive electricity, which may account for their office in rain production, and that experiments by Professor Trowbridge, of Harvard, on the effect of flames upon the electric conditions of the air would lend countenance to the belief in the effect of fires on rainfall, while the possible origination of electric currents as a result of friction in cannonades is suggested by Mr. Powers as an explanation of their assumed effect.

We may say, then, that at this stage of meteorological knowledge we are not justified in expecting any results from trials as proposed for the production of artificial rainfall, and that it were better to increase this knowledge first by simple laboratory investigations and experiments preliminary to experiments on a larger scale.

If explosions are to be tried at once then it would be necessary at least to take all possible precautions to ascertain the state of the atmosphere in all particulars before, during, and after the explosions, and to conduct and refer to the experiments rather as investigations into the effect of explosions upon the atmosphere than with the ultimate desired result in the foreground.

CONCLUSION.

The same recommendations which have been repeatedly made in my former reports as to the work to be pursued by the Division and as to the manner of advancing the forestry interests of the country

in general may be repeated, only with more emphasis than before, although with the increased appropriations and facilities provided this year, not only can certain lines of work, which the Division had tentatively laid out, be placed upon a desirable basis, but it will also be possible to devote more time and attention to the missionary work, which must needs still form part of our endeavor to change the forest policy of the United States.

B. E. FERNOW,
Chief of Division of Forestry.

Hon. J. M. RUSK,
Secretary.

REPORT OF THE ENTOMOLOGIST.

INTRODUCTORY.

SIR: I have the honor to present herewith my annual report as Entomologist for the calendar year 1890.

A summary of the work of the Division for the year has been presented in your annual report to the President, and is reprinted in the opening pages of this volume. The subject, therefore, needs no elaboration here. The articles which follow are short and condensed accounts of some of the more interesting observations and experiments of the year.

That upon the boll worm investigation is merely a report of progress and a discussion of plans. The army worm has made two destructive appearances during the year, one in Maryland and the other in Indiana, and as these appearances have an interesting bearing upon the subject of influence of climate I have devoted some little space to their consideration. Following this article I have brought together some notes upon the bronzy cut-worm, an insect which is often taken for the army worm, and the consideration of which is additionally appropriate at this time for the reason that it is commonly affected with a bacterial disease which may possibly be transmitted to the boll worm. Some observations and remedial experiments upon the horn fly of cattle are brought together as supplementary to the details in my last annual report. Four new species of the genus Icerya, recently described in INSECT LIFE, are referred to, because of their close relation to the fluted scale of California, and of the economic interest attaching to the species of the genus. Considerable work has been done in California during the past year upon the question of remedies for the scale-insects other than the fluted scale. The results of these experiments upon the so-called black scale (*Lecanium oleæ*) are given in this report and some interesting experiments upon the red scale (*Aonidia aurantii*) are mentioned in the summary of the reports of agents. Concerning this species two distinct forms have long since been known and these are considered in detail and their differences set forth. The green-striped maple-worm is an insect which has been frequently brought to the attention of the Division of late years, and in order to make its life history and the remedies against it more generally known, I have included a short account. The rose chafer (*Macrodactylus subspinosus*) has also been very prominent of late and is also treated herewith. Another insect which may possibly soon gain economic importance in this country is considered in the article headed "A New Peach Worm," while the work of the field agents of the Divi-

sion during the season is summarized in a concluding article, the full text of their reports being reserved for a bulletin.

It were premature to refer in detail to a number of minor investigations which are in progress, but I may mention the fact that I have made during the year an attempt towards repaying the people of Australia and New Zealand in some degree for their assistance in the introduction of *Vedalia cardinalis* into California, by sending them predaceous and parasitic species which may help to reduce the numbers of the codling moth, an insect which is, perhaps, more destructive in those countries than in any other part of the world. Among the insect enemies of the codling moth recently discovered by Mr. Koebele, in California, is a Neuropteron of the genus Raphidia, the larva of which is very active and rapacious and feeds extensively upon the apple worm after these have issued from the apples. A shipment consigned to Mr. R. Allan Wight, of Auckland, arrived in fairly good condition, seventeen being alive, sixteen in the pupa state, and one in the larva state. The latter fed voraciously upon the first apple worms which were offered to it. The latest advices are somewhat discouraging, as there is no certainty that the insect has survived and been colonized there. I have also made efforts to introduce some of the European parasites of the Hessian fly which do not yet occur in the United States.

That these efforts have not been successful is largely due to the fact that they had to be made through correspondence. The clause restricting travel to the United States is still maintained in the appropriations for the Division, and this seems very strange in face of the example of *Vedalia*, the successful importation of which has been worth many millions of dollars to the people of California, but which could not well have been made without sending an agent to Australia. I again urgently recommend that steps be taken to have this unnecessary restriction removed.

An interesting event of the year is the appearance of the hop fly (*Phorodon humuli*) upon the Pacific coast. This insect has up to the present season been known to occur only in Europe and in the hop fields of the United States east of the Mississippi river.

The correspondence of the Division has been rather larger than last year and about three thousand eight hundred letters have been written to correspondents in answer to inquiries and a large number of others have been answered by circular. The collections have been greatly added to by donations, purchases, and exchanges, and the amount of Museum work in the way of the determination of species, not only for investigators in all parts of the country, but for the agents of the Division and the entomologists of experiment stations, has greatly increased. As stated in my last report, this branch of the work of the Division is growing more and more onerous, and while it is extremely important, its results are shown in the reports published by those thus assisted rather than in any visible output of the Division.

The report has been kept within the limit as to length allotted to the Division. I greatly miss the opportunity of publishing extended articles upon important insects afforded in previous annual reports, but which present exigencies forbid. The insufficiency of the printing appropriation at the disposal of the Department will also not permit of the publication of as many or as long bulletins of the regular series of the Division, or of special reports, as the accumulation of information in the Division demands.

Congress has appropriated $27,500 for the use of the Division during the fiscal year 1890–'91, an increase of $7,500 over the preceding year's appropriation, and while the opportunities for investigation are increased, the no less important opportunities for placing the results of such investigations before the public are in reality lessened. The Division is in urgent need of additional facilities for publication, and also of additional facilities for office and experimental work.

A detailed list of the publications of the Division during the year will doubtless be published in the report of the Division of Records and Editing, and will, therefore, be unnecessary here, but I may state that these publications have occupied more of the time of the office force than usual. INSECT LIFE, the periodical bulletin, has been issued about once a month, and most encouraging comments concerning the usefulness of this publication are constantly being received.

Bulletin 21 of the Division was published early in the year, and is an account of the trip of one of the California agents to Australia to collect and import the parasite of the fluted scale. Incidentally some account of other injurious Australian insects is given.

Bulletin 22 contains the reports of the agents in California, Iowa, Indiana, Missouri, and Nebraska upon their observations during the year 1889, and includes particularly a discussion of the insects injurious to young tree claims in Nebraska and an important article on the insects injurious to pastures and meadows in Iowa.

The first three parts of the Bibliography of the More Important Contributions to American Economic Entomology, with index, making a volume of 450 pages, was published early in the year, and the small edition has already become exhausted.

In the regular series of bulletins of the Division, number 7 has been held open for a short review of the species of the genus Acronycta, the larvæ of which are destructive leaf eaters; but for numerous reasons it has been impossible to complete this paper, and rather than delay the binding of the set I have filled this number by submitting for publication that portion of the report affecting live stock and other animals which treats of the Mallophaga. I have also ready for publication a popular bulletin on locust ravages, which will be printed as number 23, and also Bulletin 24, which will comprise the reports of the agents of the Division for the season of 1890.

It was announced a year ago that Dr. Packard's report on forest tree insects, being the fifth and final report of the U. S. Entomological Commission, was going through the press. The final proofs were read about the 1st of October, but owing to a press of executive work the printer has not been able to run off the edition. It is a large report of nearly 1,000 pages, and is very fully illustrated.

Respectfully submitted.

C. V. RILEY,
Entomologist.

Hon. J. M. RUSK,
Secretary.

THE BOLL WORM INVESTIGATION.

In the fourth report of the U. S. Entomological Commission, which was devoted to the consideration of the cotton worm (*Aletia xylina* Say) and the boll worm (*Heliothis armigera* Hübn.), we dwelt upon the fact that in many parts of the South the damage done by the boll worm to the cotton crop exceeded that done by the cotton worm; and when we consider that the former insect is not, like the latter, confined to this one crop, but damages other staples, such as corn, pease, beans, tomatoes, and tobacco, *Heliothis* may be safely classed as one of the foremost of the so-called first-class injurious insects. In our consideration of its injuries to cotton in the report just mentioned, we gave a complete account, so far as it was possible at that time, of the characters, transformations, number of broods, method of hibernation, natural enemies, food plants, and remedies, together with summaries of less important points, such as nomenclature and geographical distribution, and concluded with a partial bibliography.

Since the publication of this report. in 1885, there has been no year when the injuries of the cotton worm, compared, for instance, with those of 1868 and 1873,—a result in no small measure due to the effective remedies discovered. But damage from the boll worm seems to have been on the increase. The edition of 30,000 copies of said fourth report was exhausted with the close of 1889, while during that year the requests for additional information were larger than ever before. During the winter of 1889-'90 Congressional influence was brought to bear for a further investigation of the boll worm, and strong letters were received from Hon. Richard Coke, U. S. Senator from Texas, and the Hon. N. C. Blanchard, member of Congress from the fourth district of Louisiana. The former was accompanied by letters from the director of the State Agricultural Experiment Station and from the mayor of Brownsville and the superintendent of the State penitentiaries, and the latter conveyed a memorial, signed by the president of the Shreveport Cotton Exchange and by the president of the Board of Trade of the same city. Both Senator Coke and Mr. Blanchard urged that a supplementary investigation be undertaken by the Department, and in view of the fact that the investigations for the present fiscal year had already been planned at the time when this matter was brought up, Senator Coke introduced an amendment to the agricultural appropriation bill in the Senate appropriating $2,500 for this purpose, which has passed and became a law July 15.

The season was so far advanced at the time when this appropriation became available that the best results which should be brought about by such a supplementary investigation were to some extent impaired. Steps were, however, at once taken to start the work for the remainder of the season, so that everything will be in readiness for more perfect work in 1891.

Before the necessary agents could be appointed and sent to the field the top crop of cotton, which is always the portion of the crop which is most damaged by this insect, had already been picked in the southern portions of the cotton belt. There was, therefore, little to be gained in sending men to what is perhaps the worst infested section, viz, the State of Texas south of the Brazos Valley. We learned from correspondence with Prof. George W. Curtis, the

director of the Agricultural Experiment Station at College Station, Texas, that he had already begun an independent investigation on the boll worm and that he would be glad to coöperate with the Department in our investigation of the same subject. With the object of assisting Professor Curtis in his investigation, we sent Mr. Nathan Banks to College Station early in August. He remained with Professor Curtis until the 1st of October, assisting him as much as possible in his work and reporting both to him and to this Division.

Prof. Jerome McNeill was also temporarily stationed at Pine Bluff, Arkansas, to conduct investigations at that point.

One of the principal features of the Hon. Mr. Blanchard's letter and the memorials from the Stock Exchange and the Board of Trade of Shreveport, contemplated the investigation of the fungus and bacterial diseases of certain caterpillars with the idea of endeavoring to convey such disease to the boll worm and also the cotton worm. As we found after investigation that Dr. A. R. Booth, of Shreveport, Louisiana, was well fitted for conducting this phase of the investigation he was entrusted with this work at that point.

Meanwhile Mr. F. W. Mally was sent first to Arkansas for consultation with Professor McNeill, afterwards to Shreveport for conference with Dr. Booth, and after surveying the ground and endeavoring to ascertain the most advantageous point for work at that time of the year he was stationed at Holly Springs, Mississippi, for the remainder of the season, where he has been making observations upon the natural history of the species and conducting experiments with remedies. Dr. Booth has already established the susceptibility through contact of the boll worm to the cabbage worm disease (*Micrococcus pieridis*), and has a very large number of cultures which we shall endeavor to carry through the winter.

Other diseases of Lepidopterous larvæ have also been experimented with, notably the one or more which commonly affect the bronzy cut-worm (*Nephelodes violans*). These diseases seem well worthy of experimentation on account of the swiftness and thoroughness of their work, and we have had our Indiana agent, Mr. Webster, collect and send a large number of these diseased cut-worms to Dr. Booth, who has successfully made cultures of the disease germ for experimentation next spring.

Professor McNeill was stationed during the latter part of the season at Pine Bluff, Arkansas, and has done some original work in the matter of remedies. It will be premature at this time to mention by name any of the mixtures with which he has been experimenting. We hope, however, when their efficacy or non-efficacy has been thoroughly established, to be able to publish results which will have considerable value as additions to our knowledge of remedies.

Mr. Mally has covered a good deal of ground in the character of his work and has discovered certain new facts concerning the habits of the larva and imago, and has found a bacterial disease of the larva, another probable disease of the moth, and also a disease of the eggs. He has reared six true insect parasites and has found a few others which are possibly parasitic upon this insect. He has found other new food-plants of the boll worm and has studied the habits of other insects feeding upon cotton bolls, the work of which is easily confounded with that of Heliothis.

THE ARMY WORM.

Two rather interesting occurrences of this well-known insect have been reported to the Department during the summer of 1890. In May we learned from the local newspapers and through the Maryland Agricultural Experiment Station of the occurrence of the worms in great numbers in Somerset and Wicomico counties, Maryland, and sent Mr. W. H. Ashmead to report upon the state of affairs. Mr. Ashmead was accompanied by Mr. Hayward, the horticulturist of the Maryland Agricultural Experiment Station, and his report is published in full in INSECT LIFE, Vol. III, No. 2, pages 53 to 57. So far as he could learn the reports of the occurrence of the worm in Wicomico County were without foundation. In Somerset County, however, he found that great damage had been done to fields of wheat, corn, and timothy. The belt of country overrun by the worms included the town of Princess Anne and extended over a radius of from 10 to 15 miles.

The usual ditching remedies were tried with a greater or less degree of success, but the outbreak would be hardly worthy of more than passing mention were it not for the fact that the character of the preceding year seems to have been different from those which we have, from past experience, been led to consider as necessarily connected with the appearance of these worms.

In the third report of the U. S. Entomological Commission, where we have given very full treatment of this insect, we have summarized our views on the subject of the reasons for the sudden appearance and disappearance of this species. We discussed previous theories, particularly those of Dr. Asa Fitch and Dr. Cyrus Thomas, and made the general statement that from an examination of the weather records the years immediately preceding Army Worm years have been nearly universally characterized by drought, while the seasons in which the worms actually appeared have been either wet or dry. From this knowledge we are unable to say with certainty, as thought by Dr. Thomas, that after one or two seasons of drought the army worm will appear. From the observed facts during the winter and early spring of a given season, however, we may form pretty accurate conclusions as to the abundance of the worms the ensuing summer, and this is especially true when the preceding summer and autumn have been exceptionally dry.

Now the interest attaching to this Somerset County incursion arises from the fact that the summer and autum of 1889 in this part of the country were considered wet. General Greely has kindly furnished the Department with a table of annual precipitation for the years 1888, 1889, and 1890 for the State of Maryland, and, although only one of the stations (Barren Creek Springs) is situated sufficiently close to the infested belt to render its reports of any value in this connection, it is evident from this station's records that the season of 1889 was extremely wet during the months of March, April, May, June, excessively so during July, rather dry during August, with about the average rainfall in September, and wet again during October and November. This station is 15 miles to the north of Princess Anne and substantially the same rainfall is to be predicted. We have, however, used the private records of one or two planters whose crops suffered, Messrs. William J. Porter, James N. Dennis, and H. H. Deshields. They have characterized the spring and fall

of 1889 as very wet. Messrs. Porter and Deshields state that the summer was also very wet while Mr. Dennis characterizes it as dry. The general conclusions which we have drawn in the report already referred to were fully substantiated for the Atlantic seaboard as a whole. The Maryland occurrence was local, and, could all the facts be ascertained we should doubtless find some explanation not at variance with previous experience.

We have, however, brought out another point in our previous writings not touched upon by others, and that is the character of the preceding winter.

In an article published in May, 1883, we showed that the previous winter had been open and that worms of all sizes had been found during the winter in the vicinity of Washington and various parts of the South. We drew the inference that damage might be expected late in the spring, particularly if the weather proved in any way wet. It is true that the summer of 1882 was one of considerable drought, but this was hardly taken into consideration in this prediction. The result was that for the first time in many years the army worm did considerable damage in the vicinity of Washington and great harm to the grain fields of northern Alabama, Georgia, and Arkansas.

To apply this to the outbreak under consideration: During the past winter the weather was remarkably open, and the season was universally characterized as mild and wet. Mr. Deshields states that it was the mildest winter ever known to the oldest citizen. The worms hibernated in numbers and Mr. Ashmead states in his report that "all the farmers and others interviewed concurred in the opinion that the winter of 1889-'90 had been unusually mild and dry, and a few reported having observed the worms feeding on warm days during the winter."

We must, then, conclude that a preceding drought is not so essential a precursor of destruction by this insect as it has hitherto been considered to be, but that injury may depend, at least in this latitude and further South, on very open winters during which the larvæ will remain active and feed and when there may possibly be an opportunity for an additional generation, or at least for an unusally early development of the moths from the hibernating larvæ.

The second occurrence of the worm took place in May in Posey County, Indiana, and was investigated by Mr. Webster, whose brief report is published in No. 3, Vol. III, of INSECT LIFE, pages 112 and 113. The overrunning of only 150 acres is mentioned by Mr. Webster, but this instance possesses considerable interest from the fact that this strip (of timothy) and the adjacent cultivated lands were situated on the second bottom of the Ohio River and were all overflowed during March, the overflow remaining long enough to destroy the young wheat. Young worms were noticed in great numbers in the 150-acre meadow on May 2, and by June 7 had entirely destroyed the timothy crop and had entered the ground to pupate.

It seems to us that this appearance can only be explained on the ground of a superior growth of the crop of timothy brought about by the overflow. Moths issuing from hibernating larvæ early in May must have been attracted by the rank growth of this meadow and must have therefore oviposited in the grass abundantly.

Other points, such as the vicinity of fodder stacks, doubtless had considerable bearing upon this occurrence, but these were not investigated.

Mr. Webster noticed an extraordinary abundance of parasites in

the Indiana meadow, principally Tachina flies, while in Maryland these seemed to have been scarce. Mr. Ashmead found the common Microgaster (*Apanteles militaris* Walsh) in small numbers, but observed many ground beetles preying upon the worms. Among these he mentions *Scarites subterraneus*, which has not been previously recorded as an enemy of the worm. He also states that the English Sparrow was observed picking out the smaller worms and feeding on them, and a few robins were engaged in the same work. He also mentions a rather curious fact in that the stench from the dead worms which had collected in the ditches was so great as to attract buzzards.

THE BRONZY CUT-WORM.

(Larva of *Nephelodes violans.*)

[Plate III, Fig. 3.]

An insect which is frequently mistaken for the Army Worm, and which has several times been sent to us by correspondents with the question as to whether it was not the well-known depredator which we have just been considering, is the large handsome caterpillar which we have called the bronzy cut-worm. A brief account of it is further appropriate here because of its being subject to an epidemic bacterial disease which may possibly be employed against the boll worm. As long ago as April, 1871, we found this insect feeding in numbers upon clover on the Iron Mountain road in Missouri and later in the same season found it upon blue-grass in other parts of the State.

In October of the same year we found it at Ithaca, New York, and again in the spring of 1872 found large numbers in the vicinity of St. Louis and reared the moth. Since then it has been sent or brought to us on a number of different occasions and we have fully studied its life history and reared from it several parasites.

In the meantime, however, it has been thoroughly written up by Dr. Lintner, the State Entomologist of New York, in his first annual report, Albany, 1882, pages 99 to 110, in which use is made of some of our manuscript notes sent him for the purpose. In his fourth report, Albany, 1888, pages 54 to 57, he gives an interesting account of the winter occurrence of this caterpillar, and shorter notes have been published by other entomologists, mainly, however, of the occurrence of the moth in different parts of the country. It will suffice for our purpose here to give a brief account of the life history of the insect which may be readily recognized in its different stages from the accompanying figures (Plate III, Fig. 3,) engraved in 1880.

The moths, Fig. 3*c*, make their appearance during the months of August and September, the females laying eggs so that the resultant larvæ will have time to feed and pass through two or more molts before winter. The eggs have not yet been specifically observed, and we know nothing yet of the exact mode and place of oviposition. The partly grown worms hibernate under sticks, stones, and other rubbish, and upon the opening of spring come forth and feed upon grass and other low-growing plants until they reach full growth. The time when they enter the ground to pupate varies from the first of June to the end of the same month, and they remain in the ground some time before transforming and issue as moths, as just stated, from the first of August on.

While they feed in the hot sun at midday this is chiefly the case with diseased worms, as normally they are essentially nocturnal. In the more southern States the species may hibernate as a moth as it is frequently captured in the winter. The very young larvæ are bright green with bare indications of the stripes which characterize the large ones. The full-grown larva is one of the largest of its family, and is distinguished from all others by the pale amber-colored head and the bronzy hue of the body, the pale dorsal and subdorsal stripes always showing distinctly on the dark highly polished cervical and anal plates. In July, 1881, we gave some account* of the alarm created in New York and other Eastern cities by the appearance of this insect in some numbers, and there published a description by which it may readily be distinguished from the army worm. This description we reproduce.

NEPHELODES VIOLANS.—*Larva:* Larger specimens fully 1.9 inches long, largest in middle of body and tapering slightly each way, especially toward anus. Color brownish bronze, the surface faintly corrugulate, but polished, the piliferous spots obsolete. A darker, highly-polished cervical shield and anal plate. A medio-dorsal and subdorsal stripe of a buff or dull flesh color; each stripe of about equal diameter (nearly .04 inch on middle joints), forming narrower, paler lines on the plates and nearly converging on the anal plate; a similar but somewhat broader substigmatal stripe, which is wavy below; between subdorsal and stigmatal stripes a faintly indicated pale line dividing the space nearly equally. Venter nearly of same buff color, with a tinge of green. *Head* perpendicular, immaculate, paler than body, rugulose, subpolished, faintly translucent, pale dingy olive, the jaws, and sometimes the mouth parts, darker. Legs and prolegs of same pale olive color, the latter with a black band at outer base. Stigmata black.

The young larva is green, but early shows the pale stripes. When about one third grown the general hue is olive-green, with the cervical and anal plates but little darker. The head is pale, greenish, faintly freckled, and with a few dark hairs; the sutures pale, the mandibles tinged with blood-red and brown at extremities, and the ocelli distinct on a pale ground, the second and third from below black, the others light. The three dorsal stripes and the narrower suprastigmatal line are very pale, greenish yellow, the broader substigmatal stripe of a clearer cream yellow, with a faint carneous tint.

One of the most marked Noctuid larvæ, at once distinguished from all others known to me when full grown by the pale, immaculate head (recalling copal), and the polished bronzy or umber color of body. The upper stripes are often obsolete or subobsolete in the middle of body, but are persistent on the plates. The bronzy color in paler specimens is due to brown and yellow mottlings, and in dark specimens becomes nearly black, while the stripes are generally minutely mottled with carneous.

Pupa: Normal, dark brown, the tip with two horizontal almost parallel spines.

The bronzy cut-worm is quite subject to the attacks of natural enemies. Professor Forbes has shown that it is often found in the stomach of the bluebird, robin, and red-winged blackbird. We have reared from the larva in Missouri two Hymenopterous parasites and a Tachinid fly. The Hymenoptera are both Braconids and belong to the same genus. They are *Rhogas rileyi* Cresson, and *Rhogas terminalis* Cresson. The first of these we have figured at Plate IV, Fig. 1. Much more effective, however, than the predatory or parasitic enemies of this insect is the bacterial disease previously referred to. This is a Micrococcus which Professor Forbes has for some time been studying, but which is not yet named. We have been familiar with it for many years, but we believe that public attention was first called to it by Professor Osborn in June, 1881. He then stated that the diseased worms would be found clinging to the stems as high up as they could reach, their bodies swollen to an unnatural size, and in the later stages exceedingly soft and ready to fall to pieces. This

* Amer. Nat., July, 1881, pp. 574–577.

disease has been noticed by us almost every year since, but was particularly prevalent in the summer of 1887, when on a trip through Indiana and Ohio and to the East it was everywhere noticed. It was an extremely difficult, not to say impossible thing, in fact, to find a single healthy worm. The hiding-by-day instinct seems entirely absent with the sick worms, which crawl laboriously up the stalks of grass and there station themselves, as described by Professor Osborn, to die and eventually to shrivel up into unrecognizable objects.

The bronzy cut-worm is also attacked by a fungus disease which was noticed by Mr. Webster in our annual report for 1886, page 579, where, in treating of the glassy cut-worm (*Hadena devastatrix*), he makes use of the following language:

> Dead larvæ were found in the earth, stretched at nearly full length, rigid, and with a parasitic fungus, a species of *Isaria*, growing from between the thoracic segments, but more frequently from the neck, after the manner of *Torrubia* from the white grub, only that in this case they affect the upper as well as the under part. This was also observed to attack the larvæ of *Nephelodes violans*.

ADDITIONAL NOTES ON THE HORN FLY.

(*Hæmatobia serrata.*)

Complaints about the horn fly have been fewer during the past summer than during that of 1889. Mr. H. M. Magruder, of Charlottesville, Virginia, wrote us, May 12, that the fly had made its appearance again in considerable numbers and was annoying cattle greatly, and one or two other complaints were received from the same neighborhood. In the vicinity of Washington, however, and in several other localities where the fly was very abundant last season, they have this year been almost unnoticed. Mr. Magruder, in writing to us on the date above mentioned, and referring to the impracticability of the application of lime to the droppings in the very large fields in his part of the State, desired instruction as to applying a preventive by means of a force pump upon the comparatively wild cattle in the large pastures. September 4 he wrote us as follows:

> About the 1st of June I made up an emulsion of kerosene according to the formula sent me, and putting it in my knapsack spraying pump with Vermorel nozzle used in spraying my vineyard, went among the cattle while they were licking salt, applying the fine spray to the patches of flies. They would abandon the animal at once on feeling the spray, some settling on others, but none returning. Next day the flies were much diminished in number. After three applications they were so diminished that I did not use the spray again for three weeks. Two more applications so thinned them that my cows and cattle have been almost free the rest of the summer. Whether owing to the spray or not I can't say, as later on they thinned out also on cattle of neighbors, who did not use anything; but it certainly looked as though the kerosene emulsion either sickened or killed them or caused them to seek other quarters. I am going to try it again when the flies get troublesome.

The experiment was not conclusive but indicates that this method of applying the oil mixture is practicable and will certainly warrant a thorough trial in case of future abundance of the flies. Two of the localities where the fly was very abundant during 1889 were at Calverton and The Plains, Fauquier County, Virginia. These two points are only 16 miles apart and the conditions seemed precisely the same at the time of our investigations. In October we wrote to Col. Robert Beverly, of The Plains, and Mr. G. M. Bastable, of Cal-

verton, asking them as to the abundance of the fly during 1890 at their respective locations. They answered as follows:

The horn fly appeared here this season about the 1st of May, and has been and is yet in great quantities, probably four times as many as last season, and has done great damage to our cows and cattle, reducing the quantity of milk and preventing the cattle from fattening and in some cases producing great sores upon them. I have an ox and three steers with patches of sores as large as your hand all over them made by these flies, and the cods of all the steers are sore from them. Where the cattle lie down the cods are black with them. I think the cattle in this county have been reduced 75 to 100 pounds from what would have been their best weight, and some cattle, favorites of them, have not fattened at all. You have not heard from us about them because we see or think there is no remedy. Their area is much extended. I saw them in force in Essex County, Virginia, and in Russell County, southwest Virginia. In neither section were they last season. The people from those sections wrote me about them. I replied there was no remedy that I knew of. I wish you could find a remedy. Possibly a very cold winter may reduce them. * * *—[Robert Beverly, The Plains, Virginia, October 10, 1890.

There has been very little complaint made by the farmers in this section. On all the cattle I have seen there has been quite a number of these flies, but nothing to compare with the number last year. In all my inquiries during the past summer none have considered the fly as a dangerous pest.—[G. M. Bastable, Calverton, Virginia, October 10, 1890.

In the article in the last Annual Report our generalizations concerning the life history of the horn fly were based upon records in the Divisional notebooks brought down to September 28, 1890. The manner in which the winter is passed had not then been determined and the matter of parasitic or probably parasitic and carnivorous insect enemies had not been discussed. The following account of the winter habit and of the insect enemies of the horn fly is given to supplement and complete the article referred to.

On the date last recorded, September 28, the flies were still as abundant as ever about Washington. From this time they decreased in numbers and practically disappeared about the middle of November. Observations made at this time in Virginia, near Rosslyn, did not result in the discovery of the Hæmatobias either about the cattle or in the stables. In one instance, which, however, was doubtful, as the insect was not captured, a supposed Hæmatobia was seen on an animal. The common stable fly (*Stomoxys calcitrans*), however, still occurred in numbers about cattle.

On December 13 a considerable quantity of dung was collected from a pasture on which cattle had not ranged for from three weeks to a month. The material contained puparia of various Diptera in considerable numbers, the puparia occurring either in the dung or immediately beneath it, and were not found in the soil below, except as the latter had been carried up and incorporated with the lower portions of the dung by the agency of angle worms. Many of the puparia were exposed on the surface, having been washed out by rains, but were in good condition.

In the dung examined two puparia of the horn fly (and proved by breeding to be such) were found, and also the larva of an Anthomyiid. Besides these were found two other species of Dipterous larvæ and the puparia of some eight species, most of which, together with other Diptera not separated as puparia from the dung, were subsequently reared.

Altogether over forty species of Diptera were reared from dung in the investigation of the horn fly. From the Hæmatobia puparia mentioned above the adults emerged January 2 and February 17. *Stomoxys calcitrans* was reared from this material January 20, and

from dung collected November 27 this species was educed May 7 and 14. The appearance in these breeding experiments of the Hæmatobias and Stomoxys was doubtless in advance of the normal period under natural conditions owing to the protection and warmth of the breeding house, but certainly indicates that the winter is passed, in the case of both these species and also with a host of other Diptera in puparia either in or just beneath dung in the open field.

The difficulty in finding the hibernating pupæ of the horn fly, especially in a locality where this insect was at no time excessively abundant, can be readily understood, and the discovery of the puparia under the conditions mentioned, together with the breeding in January and February of the adults, is sufficient evidence that the winter is normally passed in the pupa and not in the adult stage. Corroborative of this is the similar habit observed for other Diptera and particularly in the instance of the related *Stomoxys calcitrans* which, however, occurred much later in the fall, being noted in the fields as late as December 13.

February 28 Prof. John B. Smith wrote us from New Brunswick, New Jersey, as follows:

> As to Hæmatobia it hibernates as imago without any doubt, whenever it gets cold enough. They went into winter quarters for awhile and were found in stables and barns hidden away. They seem, however, to have reached the conclusion that they were mistaken in their estimate of the season and have taken to breeding again. Dr. Lockwood is breeding flies at Freehold from cow dung brought in from the fields. My correspondents from northern New Jersey inform me that larvæ are abundant in droppings, but that the flies do not seem to be plenty.

We wish that Professor Smith had given us details in confirmation of his statement that the insect "hibernates as imago without any doubt," for in our experience we were unable to prove any such condition of affairs, notwithstanding the fact that the Washington winter must be a trifle milder than that season in northern New Jersey. Dr. Lockwood's experience at Freehold coincides with our own, and we reared the flies even earlier than he did. The hibernation of the adult in this locality must be exceptional, while the hibernation of the insect in puparia is the rule not only with this but with other species of flies, some of which are popularly supposed to universally pass the winter as adults. For instance, it is the general impression that this is the case with the common house fly, but, while many individuals undoubtedly hibernate in houses as adults, we had personal evidence many years ago in Missouri of out-door hibernation in the puparium state.

PROBABLE PARASITIC INSECTS.

In the rearing of 1889–'90 someeight species of Hymenoptera were obtained from dung, several of them from puparia previously isolated, but for the most part they were obtained from the dung without its being possible to determine which, if any, of the Dipterous larvæ or pupæ they attacked. It is probable that little, if any, choice was exercised, and that the different Diptera were all more or less subject to attack. The species bred are the following:

Hemiteles townsendi Ashm. Four specimens.
Aphæreta muscæ Ashm. Very abundant.
Onychia sp. Very abundant.
Figitis (?) sp. Three specimens.
Hexaplasta sp. Very abundant.
Kleidotoma sp. Very abundant.
Diapria sp. One specimen.
Spalangia sp. One specimen.

The Onychia was frequently observed ovipositing in fresh dung apparently at random. *A. muscæ* was bred from puparia of Diptera, but with no positive evidence of its being reared from those of Hæmatobia. This species, however, was perhaps the most abundant of the parasites bred from the dung, and it is very likely that it will be ascertained to be a true horn fly parasite as well as a foe to other dung-feeding Diptera. We have figured it at Plate IV, Fig. 2.

Several species of beetles, *Staphylinidæ*, were observed to frequent the dung and to feed on the eggs of Diptera, particularly on the egg-masses of the common blue-bottle fly (*Lucilia cæsar*). The eggs of the latter were drawn out and quickly eaten or sucked and the empty shells discarded. These beetles were not observed to attack the larvæ.

CAUSE OF THE SEASON'S EXEMPTION.

The abundance of the horn fly during the summer of 1889 and its general scarcity during the summer of 1890 afford another of the common instances in insect increase and decrease. The influence of climate not only upon the insect itself but upon its natural enemies must be considered as the main factor which produces this result. The summer of 1889, it will be remembered, was marked by an extraordinary and almost continuous rainfall, while the precipitation in the summer of 1890, though great, was much less. Breeding, as this insect does in dung, it is plausible to suppose that its chances for successful transformation will be better in dung kept continually moist than in dung which dries at once. Should this supposition, which we are quite inclined to believe, be correct, the 1889 abundance and the 1890 scarcity are readily explained. The insect is so new as a stock plague, however, that the experience of future seasons must decide whether, as now seems likely, the species will be scarce in seasons of drought and numerous in summers when the precipitation is abundant.

The very commonest of the Dipterous insects which breed in cow dung through Virginia was found to be the common blue-bottle fly (*Lucilia cæsar*). In many fields Mr. Howard found that almost every dung dropped the previous day contained one or more clusters (a hundred or more eggs in a cluster) of the elongate white eggs shown at Plate VII, Fig. 2 *a*, *b*, *c*, *d*. They were almost invariably hidden from view and had evidently been laid after the dung had dried sufficiently to become a little hard on top. The eggs had then evidently been thrust into a crack and placed in little erect bunches beneath the surface. There is no danger that this insect will ever be mistaken for the horn fly in any of its stages except that of the young larva. The eggs are comparatively slender and much longer than those of the horn fly, and the full-grown larva and the puparium are twice as large as the corresponding stages in the latter insect. The young larva, however, may be distinguished by the lack of the ridged lamellar structure of the head, so noticeable in the corresponding stage of the horn fly. From abundant material brought in by Mr. Howard it was ascertained that an entire generation of the blue-bottle fly averages in midsummer from ten to fourteen days in duration. The numbers in which the adults issue from the dung are almost inconceivable—every morning for several days the breeding cage was apparently full of a swarming mass of flies.

SOME NEW ICERYAS.

[Plate I.]

No person living in the State of California will for an instant doubt the importance of carefully studying the habits and characters of any new species of the now well-known genus Icerya. Up to the present year but two species of this genus have been known. The one is the sugar-cane pest of Mauritius (the *Pou blanc* of the French planters), scientifically known as *Icerya seychellarum* Westwood, or *I. sacchari* Signoret, and the second is the now celebrated fluted scale of California (*Icerya purchasi*), to which we have devoted so much attention during the past four years and which has occupied many pages in annual reports prior to this one.

During the present year no less than four new species have been added to the two already known. One of these has been described by Mr. J. W. Douglas as *Crossotosoma ægyptiacum*, but upon careful study we have concluded that it should be more properly placed in the genus *Icerya*. It may be popularly called the Egyptian Icerya. The other three have been editorially described in INSECT LIFE under the names: *Icerya rosæ*, the rose Icerya; *Icerya montserratensis*, the Montserrat Icerya, and *Icerya palmeri*, Palmer's Icerya. The full technical descriptions of these new species will be found in INSECT LIFE Vol. III, No. 3, pages 94 to 105, and need not be repeated here.

The rose Icerya was sent to us last March by Passed Assistant Paymaster H. R. Smith, U. S. Navy, from Key West, Florida, on a limb of rosebush, with information that rosebushes on the Key were greatly troubled by the insect, which caused the stems to dry and the leaves to fall. It seems to infest other trees, including the sugar apple, lime, and lemon. We have shown the adult insect and its appearance upon rose on Plate I, Figs. 1, 2, and 3.

The Egyptian Icerya occurs in the gardens of Alexandria, Egypt, appearing first on the Banyan tree and spreading to many other plants. It has killed off many trees and has caused great alarm. A striking peculiarity of the species is the possession by the female of long waxy projections which shower down from the trees when a breeze is blowing.

The Montserrat Icerya occurs upon the Island of Montserrat, West Indies, and infests there a species of *Chrysophyllum*, known to the inhabitants of the island as Galba or Galaba tree. It is also stated to occur, though less abundantly, upon fig and citrus trees. This species resembles the Egyptian Icerya in the possession of the long waxy projections. (Plate I, Figs. 4 and 5.)

Palmer's Icerya occurs upon grape in the Province of Sonora, Mexico, where it was collected by Dr. Edward Palmer in 1887. The specimens received occurred upon the grape leaves along the main ribs and principally along the under sides in great numbers. Dr. Palmer found only one variety of grape infested, namely, the Muscat of Alexandria. (Plate I, Figs. 6 and 7.)

There is danger that this last species and the one occurring in Montserrat may some day make their appearance within our boundaries, and the fruit growers of Florida should take all possible pains to prevent such introduction. They would be justified in quarantining against plants from the West Indies until authoritatively

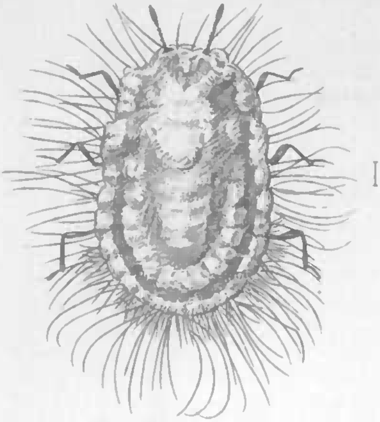


Fig 1

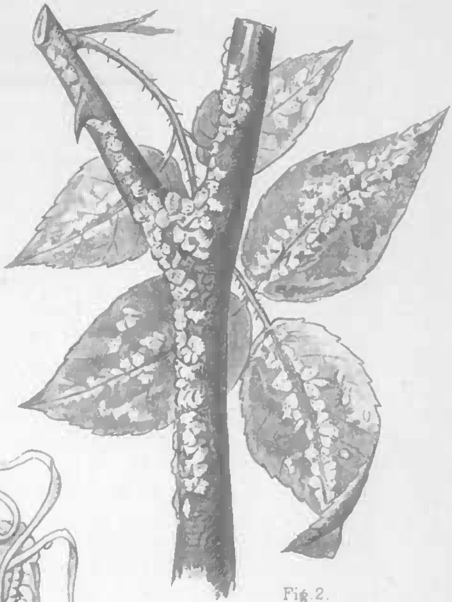


Fig. 2.

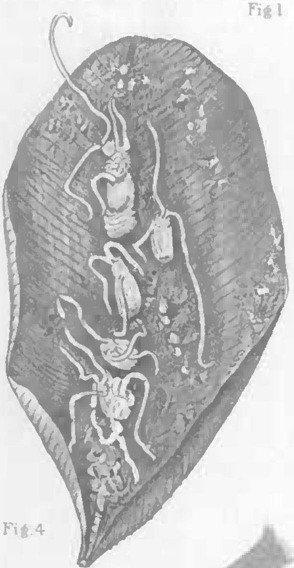


Fig. 4

Fig 5.

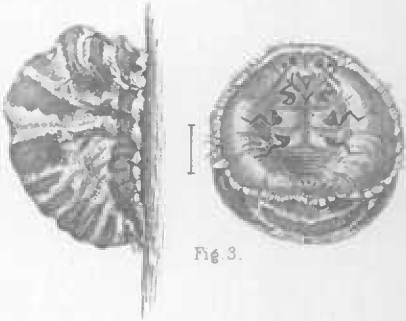


Fig. 3.

Fig. 6

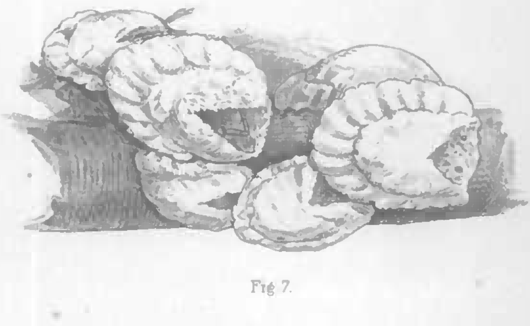


Fig 7.

Geo. S. Harris & Sons Lith. Phila.

examined, as would also the people of Texas and California against plants from Mexico. We shall, as soon as the most favorable opportunity offers, endeavor to colonize the Vedalia on the infested plants of Key West.

EXPERIMENTS AGAINST THE BLACK SCALE.

(*Lecanium oleæ* Bernard.)

[Plate VII, Fig. 1.]

The so-called black scale (*Lecanium oleæ*) has for a number of years been a somewhat serious pest in certain of the California orange and lemon groves. Originally a foe to the olive, it has spread to various other trees and is found commonly on the oleander, peach, and apricot, as well as upon citrus trees. It secretes a large amount of honey dew, and is hence followed by a greater abundance of the smut fungus (*Fumago salicina*) than are any of the other commoner scales. It is an extremely prolific species, although probably having but one annual generation, and would doubtless become a scourge were it not for the fact that it is extensively parasitized by *Dilophogaster californica*, a Chalcid fly which breeds rapidly and is at times very abundant. In 1880 Professor Comstock found that at least 75 per cent of the black scales upon more than one tree in the vicinity of Los Angeles had been destroyed by this parasite, while in 1889 Mr. Coquillett reported an almost equal destruction of the scales from the same cause. A curious fact is that while the Black Scale is directly or indirectly of European origin, the parasite evidently belongs to the Australian fauna, nothing like it being known to occur in Europe.

Californians as yet have done little in overcoming this specific scale, their attention having been so largely occupied with the more important fluted scale (*Icerya purchasi*) and red scale (*Aonidia aurantii*). With the disappearance of the former, however, through the work of the Cardinal Vedalia, and the recent success and great reduction in the cost of the gas treatment of the black scale, the San José scale (*Aspidiotus perniciosus*), the flat or soft scale (*Lecanium hesperidum*), and others of less prominence will doubtless receive more attention.

Mr. Ellwood Cooper, of Santa Barbara, has probably paid more attention to the matter of remedies for the black scale than any other California horticulturist, and after somewhat extensive experiments with the caustic washes and whale oil soap and other substances such as hot tobacco water, has finally fallen back upon the substance which we should have first recommended, viz, kerosene emulsion, which he applies hot and makes in the following manner:

> Five gallons best kerosene oil, 150° test; 1¼ pounds good common soap or one bar and a half of soap usually sold as pound packages; 2½ gallons of water. This makes the emulsion. When using dilute 6½ to 7 gallons of water for each gallon of oil and to this mixture add 2½ pounds of good home-made soap dissolved in boiling water. All this mixing is done with hot water. We usually have the solution up to 140° in the tank from which we spray.*

Our attention was called to the desirability of further experiments last September by Prof. W. A. Henry, director of the Wis-

*Biennial report of the State Board of Horticulture, 1885-'86, Sacramento, 1887, p. 378.

consin Agricultural Experiment Station, and at his suggestion we sent Mr. Coquillett to Chula Vista, California, for the purpose of making a trial of a modification of the Nixon pump, invented by Mr. E. S. Goff, of the Wisconsin Station, whereby kerosene is drawn from one vessel, water from another, and the two mingled in the chamber of the pump and thrown from the nozzle, in Professor Henry's words "as a very fine emulsion." The object of the modification was to do away with the trouble and expense of keeping the kerosene properly suspended in the water. We were glad to have an opportunity to test the modification, although realizing that a mixture made in this way would not be an emulsion proper. We therefore instructed Mr. Coquillett to conduct certain experiments on the black scale at Chula Vista with this machine and to check them by a series of tests with a carefully prepared emulsion.

The results can be best presented in Mr. Coquillett's own words, as follows:

The inclosed figure illustrates the pump in question, and I have added in pencil a sketch of the attachment to this pump as first used by Professor Goff, of the Wisconsin Experiment Station. In spraying kerosene upon the tree the water or soapsuds is drawn up by the larger hose and the kerosene by the small tube attachment, the two being drawn up by the same operation of the pump, mingled together and sprayed upon the trees. There is a stopcock in the upper part of the tube attachment by means of which the quantity of kerosene drawn up by the pump may be regulated.

I tested this pump by using soapsuds and kerosene according to your formula, one-half pound of hard soap dissolved in hot water, then diluted to make 28 gallons, to be used with 2 gallons of kerosene. After adjusting the pump so that it would draw up 2 gallons through the tube attachment at the same time that it would draw up 28 gallons through the large hose, I sprayed several trees with the above mixture and also sprayed some of it into a bottle in order to ascertain how long it would take for the kerosene to separate; it produced a whitish emulsion similar in appearance although a shade lighter in color than that made in the ordinary way. The oil remained in suspension for three or four hours. On the morning of the third day nearly all of the oil had separated out, forming a layer of pure oil over the surface of the soapsuds. I also made an emulsion of the above ingredients in the ordinary way, dissolving the soap in 1 gallon of water by boiling, and while hot added the kerosene and pumped this back into the same vessel again through the spraying nozzle, continuing this for about five minutes; this formed a thick, creamy substance which diluted perfectly with water, and I added water to it until the whole measured 30 gallons.

Some of this I sprayed into a bottle as I had done with the previous emulsion, and on the morning of the third day only one third of the oil had separated out. It thus appears that when the kerosene and soapsuds are drawn up separately by means of the tube attachment, the emulsion formed is only one third as stable as that made in the ordinary way. Whether or not this will make any difference with the effect of the kerosene on the trees and insects sprayed with it can not be determined at the present time, as it will require several weeks for the kerosene to exercise its full effects upon the trees and insects. I also used pure water in place of the soapsuds, but after remaining quiet in the bottle that I sprayed some of it into, all of the kerosene separated out at the end of about three minutes. I have sprayed several trees with each of the three emulsions mentioned above, and will note the comparative effects of each and report to you later on.—[September 24, 1890.

I have just returned from Chula Vista, where I went to ascertain how my experiments with Professor Henry's pump turned out. At my previous visit, September 20, I applied the kerosene according to Hubbard's formula (kerosene, 6⅔ gallons; hard soap, 1⅞ pounds, and water enough to make 100 gallons), both by making an emulsion of it and also by emulsifying it at the time of spraying it upon the trees with Professor Henry's pump, but I was unable to see any difference in the effects. In neither instance were the trees injured, nor were the *Lecanium oleæ* and *hesperidum* exterminated. The trees operated upon were less than 5 feet tall and were lemons and olives. I sprayed one of the olive trees with the above emulsion, emulsified in the usual manner, with a solution of arsenic and bicarbonate of soda added, 1 pound of each to 864 gallons of the emulsion, but this did not prove fatal to the *Lecanium oleæ* sprayed with it. I also used the emulsion about one third stronger

than above indicated (kerosene, 10 gallons; soap, 1⅜ pounds; water enough to make 100 gallons), and sprayed it upon one olive and three lemon trees with Professor Henry's pump; the lemon trees were not injured but several leaves at the tips of some of the branches on the olive trees were killed; but the *Lecanium oleæ* and *hesperidum* were not all of them destroyed by the wash. At the above proportions, each gallon of this emulsion would cost about 2½ cents.

These experiments lead me to believe that the effect of the emulsion is essentially the same whether it is first emulsified in the ordinary way or by the use of the pump sent by Professor Henry. At the time of making the above tests I also tried the resin wash according to the formula given in my last year's report to you (resin, 18 pounds; caustic soda, 5 pounds; fish oil, 2½ pints, and water enough to make 100 gallons); this I sprayed on an olive tree and two orange trees; neither of the trees were injured by the wash; on the olive I found only one living *Lecanium oleæ*, but on the orange trees neither myself nor Mr. Adams, Professor Henry's foreman, were able to find a living *Lecanium hesperidum*. This wash costs less than 1 cent per gallon.—[October 28, 1890.

THE GREEN-STRIPED MAPLE WORM.

(*Anisota rubicunda* Fabr.)

Order LEPIDOPTERA; Family DRYOCAMPIDÆ.

[Plate V, fig. 3; Plate VI.]

Our attention is drawn from time to time to the ravages of the larvæ of *Anisota rubicunda* on soft maple trees, particularly in the central Western States. These depredations are the more noticeable and serious on account of the importance of the swamp or soft maple in all forest and ornamental plantings in the West, where it is one of the favorite trees on account of its rapid growth and the minimum of care and attention needed in its propagation. The sole drawback is the liability of its being defoliated once or twice yearly by the larva under consideration, and this has led, in frequent instances, to the replacing of these trees by other and perhaps less desirable varieties. This course is entirely unnecessary, as the maple can be easily protected by the application at suitable times of either of the common arsenical poisons, Paris green or London purple.

A very characteristic onslaught of the green-striped maple-worm has been experienced the past summer at Lincoln, Nebraska, and seems to have been left to run its course unchecked. We give, as of interest in this connection, a view of the main building of the State University with a row of large maple trees in front defoliated by this insect. This illustration is reproduced from a photograph obtained in July last for us by Mr. Lawrence Bruner, and indicates at once the thoroughness with which maples are sometimes stripped by these larvæ and the neglect by the proper authorities in this instance of all measures against them. We have seen similar complete defoliation in years gone by on the grounds of the State Agricultural College at Manhattan, Kansas, and on those of the State University at Lawrence. The frequent recurrence of this insect will warrant the reproduction, in the main from our Fifth Report on the Insects of Missouri, of a brief account of its range, life history, and the preventive and remedial measures to be employed against it.

RANGE AND LIFE-HISTORY.

While especially abundant in the West, this insect has a wide

range, extending through the Eastern States and Ontario. It has been observed as far east as Brunswick, Maine, by Dr. Packard, and in the District of Columbia it not infrequently occurs in great numbers and attacks both the swamp and silver maples. In the West it is reported more frequently from Illinois, Missouri, Iowa, Nebraska, and Kansas, in most of which States the soft maple is indigenous, a fact which accounts for the excessive multiplication of the insect there as compared with the more eastern sections of the country.

It feeds on other maples and presumably on all species of the genus Acer, and when forced to from necessity will feed on oak, though normally never found on that genus of trees, and probably incapable of full development thereon.

The eggs are deposited by the parent moth in batches of thirty and upward on the under side of leaves. The number matured by a single moth is large, in one instance 145 eggs were laid by a moth in captivity and in another 102 eggs were laid. The insect died in the latter instance before oviposition was completed, as examination revealed many more eggs still in her abdomen. The egg is about 0.05 of an inch long, suboval, slightly flattened, pale greenish, becoming yellowish and showing the black head of the inclosed larva just before hatching, and is hatched in eight or nine days after being deposited. The larvæ undergo four molts and reach full growth in about a month, when they enter the ground and transform to pupæ.

The worms (Fig. 3 *a*) are longitudinally striped with pale and dark green lines, and are chiefly distinguished by two anterior projecting black horns on the top of the second segment, and by having segments 10 and 11 a little dilated and rose-colored at the sides.

The pupa (Fig. 3 *b*) is of a deep brown or black color, very much roughened and armed with curved horns and points about the anterior extremity and also on the last joint, which terminates in a long bifurcate projection. The pupæ of the first brood give forth the perfect insect in fourteen to sixteen days, those of the second brood usually wintering over in the ground. In the West there are usually but two broods in the year, but experiments here in the District indicate that three broods are occasionally produced.

The pupa, before giving out the imago, works its way to the surface by the aid of its spines, allowing the ready escape of the moth. The moth is of a pale yellowish color shaded with pink, as in the figure (*c*) which represents the female. The male has a smaller abdomen and broad bipectinate antennæ. Different specimens vary greatly—the yellow predominating in Western and the rose-color in Eastern specimens, while others again, especially from the West, are nearly or quite white in color—this form having been unnecessarily described as a new species by Mr. A. R. Grote.

PARASITES.

We mentioned in the Missouri report cited a number of insect parasites, and we believe the list has not been added to by subsequent writers. These are: *Tachina anonyma* Riley, *Belvosia bifasciata* Fabr., *Limneria fugitiva* Say. We have in our notes, however, the record of the breeding of an egg parasite, probably either a *Telenomus* or a *Trichogramma*, by Mr. William Saunders. These parasitic insects very effectually aid in the control of the worm, which in fact seldom occurs two years in succession in injurious numbers.

MEANS AGAINST.

Spraying with Paris green or London purple in the proportion of 1 pound to 125 to 150 gallons of water as soon as the young larvæ are noticed, or a week or ten days after the moths appear in the spring, is at once the simplest and most effective remedy. Apparatus suitable for this work has been repeatedly described and illustrated in various publications of the Division, and now that the benefits of spraying against nearly all insects have been so conclusively and repeatedly shown, such apparatus should certainly be in the possession of every progressive farmer or orchardist, and also of every municipality. The initial cost would be more than saved the first season. For spraying large trees an ordinary direct discharge nozzle will answer very well, or, better still, the Nixon nozzle, made by A. H. Nixon & Co., Dayton, Ohio, from whom also a complete spraying outfit may be obtained if desired. If the larvæ have been allowed to reach full growth so that spraying will be of no use, great numbers of them can be entrapped and easily destroyed, as stated in the report cited, by digging a trench either around the individual trees or around the groves or belt. The trench should be at least a foot deep, with the outer wall sloping under. The larvæ usually wander from the trees before entering the ground, and will collect in numbers in the trench or bury themselves in the bottom, and may then be easily killed.

Their numbers may be reduced also by keeping a sharp lookout for the moths and eggs during the latter part of May, when both may be destroyed in large quantities.

A NEW PEACH PEST.

(*Ceratitis capitata* Wied.)

Order DIPTERA; Family TRYPETIDÆ.

[Plate III, Figs. 1 and 2.]

A dangerous enemy to the peach crop exists in Bermuda, as we have ascertained during the past season, and the frequent importation of fruit from that island to this country renders possible the introduction at any moment of this injurious insect into our territory. We have, therefore, taken some little pains to ascertain all that is known about it. Our material has been furnished us by Mr. Claude W. McCallan, of St. George's, Bermuda, and a preliminary article upon the species was published by us in INSECT LIFE, Vol. III, No. 1, August, 1890. The insect is a two-winged fly of the family *Trypetidæ*, and is allied to the apple maggot (*Trypeta pomonella*) of this country.

Infested peaches were received from Mr. McCallan in April, and early in May the adult flies were reared and proved to be the *Ceratitis capitata*, long since known as a pest to the orange crop in various parts of the world, but not yet found within the limits of the United States. The regions most affected are the East Indies and the Azores Islands, where the insects abound upon citrus fruits. The same or a closely allied species is found upon the Island of Malta, and is at present being investigated by a committee charged by the governor of that English possession with the preparation of a report. In Spain, Algeria, and Sicily a species known as *C. his-*

panica, but which may possibly be the same insect which we have under consideration, has been found and has been studied recently by Dr. O. Penzig in Sicily. The female penetrates the skin of the half-grown orange and lays her eggs at the depth of from 1 to 3 millimeters and in a few days the larvæ hatch and burrow through the skin and into the pulp of the fruit, rendering injured fruit partly recognizable by a brown or olive spot, which soon extends to from 3 to 5 centimeters in diameter. The original puncture is always noticeable and the larva returns to it frequently for air, placing its anal spiracles against the opening. The orange soon falls to the ground and in the space of fifteen days, more or less, the larva issues either through the original opening, or through another one made for the purpose, and enters the ground, where it transforms to pupa, remaining in this condition only a few days. There are presumably a number of annual generations. The orange is preferred to lemons and other cultivated citrus fruits, which are, however, attacked, as also peaches, figs, and azaroles. Curiously enough in Liguria Dr. Penzig found it damaging peaches, but he was not able to verify its presence in oranges or lemons. The remedy proposed was to collect and destroy the infested fruit or to submerge it for a short space of time in water. As a means of destroying infested fruit he proposes to place it in a ditch, cover with a layer of caustic lime, and thus convert the whole mass into a valuable fertilizer.

In Bermuda the species which we are considering seems to have the same peculiarity as that observed by Dr. Penzig in Liguria, in that it has forsaken citrus fruit for peaches and probably for Surinam cherries, mangoes and probably also for the Loquat or Malta plums. It has been known to infest the peach for twenty-five years but has not actually been reared so far as we can find from any other fruit. At our request Mr. McCallan searched for the flies upon the citrus trees and found a few specimens lodging upon some lime trees and fruit. No damage to this fruit, however, seems to be known in that locality. Oranges and lemons are very little grown owing to diseases of every kind and in particular (judging from Mr. McCallan's description) the foot rot (*mal de goma*) and rust. It is not unlikely that this partial abandonment of citrus culture and the destruction of the trees from disease was the cause of the transfer of the attention of the Ceratitis to peach. Just at this time of writing, however, we have received a letter from Mr. McCallan who states that he has been informed by a Mr. Swainson, a reliable man and a great observer of nature, that he had in his yard some bitter Seville oranges, from which marmalade is made, so badly attacked by this fly year after year that he cut the trees down. Other persons living in the vicinity where this sour orange is to be found wild and who market the fruit at Christmas time for the purpose of making marmalade told Mr. McCallan that they had never seen any of the oranges injured in the slightest degree by the maggots which are to be found infesting the peach.

Owing to damage done to the peach crop many persons have cut down their trees and peaches are now comparatively scarce, although formerly they were most abundant and could almost be said to grow wild. This tree blossoms in January and when the fruit is one third grown it is punctured by the fly. It continues to grow but instead of ripening suddenly becomes quite soft and decayed and drops from the tree to the ground full of maggots and perfectly useless. The insect is shown upon Plate II in all of its stages. The larva leaves

the fruit and to transform enters the ground from one fourth to 2 inches below the surface. The development is very rapid and there must be from six to eight generations in the course of a year provided food is at hand, and when peaches are not obtainable the other fruits just mentioned will without doubt be attacked. The Surinam cherries and mangoes ripen during the summer months while the Malta plums blossom in October and ripen about the following March. These fruits, therefore, with the Peach, will suffice to carry the insect through an entire season.

Owing to the fact that the female deposits her eggs under the skin of the fruit, the application of arsenical poison will be of no avail, but the collection and destruction of the fruit through any one of the ways proposed by Dr. Penzig will prove an adequate preventive provided it is done in concert over a given neighborhood and thoroughly done. It will not suffice to simply collect and destroy fallen peaches, as from Mr. McCallan's information the Malta plums are in fruit at the same time. The latter, therefore, should be also watched and all fallen fruit gathered and destroyed. There may be other fruit infested by the same insect which will also have to be watched and in localities where the Surinam orange grows it will also be fruiting at the same time and examination should be made for the purpose of ascertaining whether this fruit is also infested.

Mr. McCallan is of the opinion that the insect was originally introduced into Bermuda during the American civil war in cargoes of fruit brought from the Mediterranean region. These cargoes were intended for the American market but from stress of weather and other causes the vessels had to put in at Bermuda for repairs, etc., and the insects finding a congenial habitat, flew out and began to reproduce.

Judging from what has been written about this species it is a tropical insect and there is consequently little danger that it will thrive in the Northern States, but peaches are grown extensively in Georgia and many fruits which are liable to be attacked are cultivated in Florida. Although peaches are not now received in bulk from Bermuda, the accidental importation of the pest is always possible. Once imported into Florida its extermination would be almost impossible. We send out this note of warning for the benefit of those interested.

THE ROSE CHAFER.

(*Macrodactylus subspinosus* Fabr.)

Order COLEOPTERA; Family SCARABÆIDÆ.

[Plate V; Figs. 1 and 2.]

Inasmuch as we have not hitherto treated of this notorious insect in any of the annual reports of this Department we have thought best to introduce here a condensation of an article which we published in the April number of INSECT LIFE (Vol. II, No. 10), and which gives a fair summary of the life history of the species with an account of the remedies. Some account of this insect is particularly timely in the present report for the reason that the season of 1890 since the publication of the original article) has been marked by an extraordinary abundance of this insect in certain sections. Some

points brought out in our own correspondence during the summer and by the work of other entomologists, particularly Professor Smith, of the New Jersey Experiment Station, will also be referred to.

NATURAL HISTORY.

According to Harris the female beetle lays her eggs to the number of about thirty, about the middle of July, at a depth of from 1 to 2 inches beneath the surface of the ground. He does not state the favorite place for oviposition, but in our experience the larvæ are especially abundant in low, open meadow land or in cultivated fields, particularly where the soil is light and sandy. Harris states that the eggs hatch in about twenty days, and, while the period will vary with the temperature, the larva is found fully grown during the autumn months. With the approach of cold weather it works deeper into the ground, but in the spring will frequently be found near the surface or under stones and other similar objects, where it forms a sort of cell in which to pupate. In confinement the pupa state has lasted from two to four weeks. The perfect beetle issues in the New England States about the second week of June, while in the latitude of Washington it is seen about two weeks earlier. It appears suddenly in great numbers, in conformity with the habits of other Lamellicorn beetles, *e. g.*, our common May beetles (genus *Lachnosterna*). It remains active a little over a month and then soon disappears. The species produces, therefore, but one annual generation, the time of the appearing of the beetle in greatest abundance being coincident with the flowering of the grapevine.

FOOD PLANTS AND RAVAGES.

The food of the larva consists of the roots of grasses and probably also of other low plants. Whether it also feeds on the rootlets of trees and shrubs has not been definitely ascertained, although the larvæ have been found quite numerously around the bases of oak trees, near Washington, both by Mr. Koebele and Mr. Schwarz. We found them quite numerous in the sandy lowlands of the Merrimac Valley, New Hampshire, on cultivated ground, where they must have fed on the roots of various weeds or on those of meadow grass and cultivated rye and maize. It is probable, however, that they occur yet more numerously in unplowed pasture and meadow land than in cultivated fields. We have also recorded the fact that they exceptionally feed upon the egg-pods of the lesser migratory locust or grasshopper (*Caloptenus atlanis*). The beetle has a partiality for flowers, but also feeds upon leaves of various trees and bushes and attacks certain fruits. It has a predilection for the flowers of roses, wild as well as cultivated,* and, in the experience of many observers, prefers white roses to red ones. Harris states that the beetle was first noticed on the rose (hence its popular name), and that it afterward acquired the habit of feeding on grapevines and fruit trees. Another favorite food is the blossom of the grapevine, with a decided preference for that of the Clinton. Flowers of raspberries and blackberries do not escape its ravages. Mr. E. H. Miller states, in the American Agriculturist (see Amer. Nat., v. 17, 1883, p. 1291), that the flowers of *Deutzia scabra* are even preferred by the beetle to those of the grapevine. The blossoms of the various

---

* The Cinnamon Rose (*Rosa cinnamonica*) is said to enjoy immunity.

species of *Spiræa* are often crowded with the beetles, and the same may be said of the blossoms of the sumach, the common ox-eye daisy, *Magnolia glauca*, mock orange, and some other plants. This list could be greatly extended, but we close it with the statement that the beetles also devour the blossoms of *Pyrethrum cinerariæfolium*.

The foliage of most, if not all, of our cultivated fruit trees, and especially apple, pear, peach, cherry, and plum, at times suffers greatly, the two last-named trees being apparently more attractive than the others. The foliage of cultivated grapevines is almost as eagerly devoured as the blossoms, and the leaves of oak, alder, and other forest trees also serve as food. Of low-growing plants the beetles cut the leaves of strawberries, rhubarb, and of nearly all garden vegetables, as also of sweet potato, corn, wheat, grass, and many wild plants.

Not satisfied with this amount of damage, the beetles attack the fruit of peaches, cherries, apples, and grapes when just forming.

The statement that the beetle is poisonous has no foundation in fact.

REMEDIES.

It has been assumed by most writers that we can not successfully attack the rose chafer in any of its earlier stages. To search for the eggs in the ground would be impracticable. It does not, however, follow because of the poor success that has generally resulted from attempts to destroy similar larvæ that they can not be successfully destroyed. In the case of the common European cockchafer (larva of *Melolontha vulgaris* and *hippocastani*) and of our own white grub (*Lachnosterna fusca*) the methods adopted have consisted of plowing and hand-picking. The experiments made, however, on a similar larva with the kerosene-soap emulsion, as narrated in INSECT LIFE (Vol. I, p. 48), clearly show that we have in this insecticide a means of successfully destroying the bulk of the larvæ of the rose bug wherever they are known to be sufficiently abundant to justify such treatment. A thorough investigation should be made in the direction of ascertaining the preferred breeding grounds of the species, and it were rash to say here that we have no effectual mode of preventing the insect, notwithstanding the disfavor in which this mode of warfare has been held in the past.

It is evident, however, that for the present we should concentrate our efforts on the destruction of the beetles especially when they first issue from the ground and congregate in the garden on our roses, grapevines, and fruit trees. A brief statement of the various methods that may be employed for this purpose may prove advantageous. Hand-picking and killing the beetles either by crushing them or throwing them into hot water, or water having a scum of kerosene upon it, has proved useful and satisfactory in a limited way, as also the shaking and knocking down of the beetles into pans or upon sheets saturated or smeared with coal oil.

These measures are best carried out and most satisfactorily in the early morning hours and toward evening, as the beetles are then more sluggish and not so quick to take wing as they are during the heat of the day. White roses, Spiræas, or Deutzias, planted on a place, will attract great numbers of the beetles, and thus not only facilitate the destruction of these last, but act as a kind of protection to other plants.

As to other topical applications intended to destroy the beetles, whether directly or by poison taken with the food, the experience with the arsenites is that they are of little avail, and the experience with other materials, like hellebore and pyrethrum, has been so conflicting that we can not consider either of them reliable or satisfactory. Pyrethrum would seem to have given on the whole the most satisfactory results.

The trouble with all these remedies is that the beetles during their brief season continue to issue from the ground and to congregate upon their preferred plants in such numbers, under favorable circumstances, that however fatal an application may be it has to be continued, and the most persistent may justly become discouraged in a fight with these beetles when they are abnormally abundant and swarm to the extent we have known them.

With this insect as with many others success will only follow diligence in the combined application of the insecticides that have been found effective, and the persistent shaking on to sheets or stretchers saturated with coal oil. A few choice plants may be protected by covering with netting. Another protective measure is to dust the plants with air-slacked lime or gypsum, or to spray with lime water, from one half to one peck of lime to a barrel of water.

ADDED EXPERIENCE DURING THE SUMMER OF 1890.

Since the publication of the article in INSECT LIFE we have had some interesting correspondence on the subject of the Rose Chafer.

Mr. J. S. Strayer, of Port Republic, Virginia, wrote, under date of July 2, emphasizing the fact that the insect breeds in sandy land and that it has never been known to attack vegetation upon clay lands. This statement is exaggerated, as the beetle is a strong flyer and when sufficient food is not found in its breeding places it will fly to the nearest point where food is abundant and will attack it whether upon clay or sandy land. An interesting point which shows the certainty with which the breeding in sandy soil is known, is brought out by Mr. Strayer in a statement to the effect that it has even been recommended by gentlemen in his neighborhood to place clay around the roots of grapevines as protection. This recommendation is of little or no value under the circumstances.

Mr. John K. Hoyt, of Luther, North Carolina, wrote us July 21 that jarring the vines and catching and destroying the beetles made no perceptible diminution in their numbers. He thought his entire grape crop was doomed, but after spraying a row of one hundred vines with London purple, at the rate of 1 pound of the poison to 150 gallons of water, the beetles entirely deserted them within two days. The spraying was done on May 29, so that the disappearance was entirely produced by the remedy.

June 19 we received a letter from Mr. E. H. Wynkoop, of Catskill, New York, reporting upon some experiments with pyrethrum (4 ounces to 5 gallons of water) and with hellebore without effect. Shaking upon a stretcher saturated with crude petroleum he found quite effective. A neighbor told him that he had driven the beetles from his vineyard by burning pieces of old rubber between the rows.

Mr. S. Justus, of Mentor, Ohio, wrote, June 22, and again November 27, concerning his use of a mixture of unslacked lime and carbolic acid in water in the proportion of 1 bushel of unslacked lime to 1 quart of acid and 50 gallons of water. He applied the dose

freely and his vines looked white when he finished. He sprayed at the rate of 5 acres per day and lost no grapes afterwards. The mixture had no injurious effect on the vines and the experiment was satisfactory for the reason that a large untreated check patch was left, on which the crop was entirely destroyed.

In none of the localities mentioned, however, was the rose chafer as abundant as it seems to have been in parts of New Jersey and Delaware. The numbers in which they occurred in the two latter States, as described by Professor Smith, Mr. Beckwith, and others, would seem almost incredible to one who has not seen one of the great incursions of this species. The result was that neither of the gentlemen mentioned were able to find any remedy which would effectually protect vegetation. Myriads of beetles were destroyed but their places were filled by others, and by sheer force of numbers the effect of all remedial work was vitiated. Professor Smith found that there was scarcely a plant which they did not eat, although flowers and some fruits are always preferred. He experimented with pyrethrum, tobacco, London purple, powdered naphthaline, pure and mixed with carbonate of lime, hellebore, foxglove infusion, digitaline, quassia and copper compounds, iron solution, kerosene emulsion, corrosive sublimate, sludge-oil soap, and a mechanical apparatus consisting of an umbrella with a sack attached. In his opinion the only way to save the crops is to plant spiræa, roses, or blackberries between some rows of the vineyard. These plants are preferred by the Chafers, and by persistent collecting they can be kept from the grapes.

The experience of the past season was discussed at the meeting of the Association of Economic Entomologists at Champaign, Illinois, early in November, and the report of this meeting will be found in INSECT LIFE, Vol. III, No. 5. An article by Professor Smith, reprinted from Garden and Forest, will be found in INSECT LIFE, Vol. III, No. 3.

THE WORK OF FIELD AGENTS.

A BRIEF STATEMENT OF THE WORK OF THE FIELD AGENTS OF THE DIVISION.

Mr. D. W. Coquillett, the agent stationed at Los Angeles, California, has devoted most of his time during the past year to the further improvement of the apparatus and methods used in fumigating orange trees as a remedy for the red scale (*Aonidia aurantii* Maskell). This process, which is the outgrowth of the experiments which we began at Los Angeles in 1887, and which was described in full in our annual report for that year, was, by the work of the season of 1889, much simplified and the cost of its use was reduced about one third. The expensive machinery figured upon Plates IV, V, and VI of the 1887 report has been greatly simplified, with a corresponding reduction in cost. During the present season still simpler apparatus has been devised and the arrangements have been so perfected that it is now possible for the planter to fumigate his orchard at the rate of thirty to forty trees a night. Most large orchardists, however, use as many as six tents at once, and in one case four men, using six tents, fumigated two hundred and forty trees in one night. During the past season over twenty thousand trees have been fumigated in Orange County alone, and the red scale is being rapidly

reduced in numbers. Mr. Coquillett is convinced that better results are obtained than by the use of any kind of spray, and many instances have occurred where upon large trees treated with the gas he was unable to find a single living red scale, a result which it would be hardly possible to obtain by spraying. An interesting point which has been brought out is that the trees are less liable to injury when fumigated at night than they are when operated upon in the daytime, while the gas is just as fatal to the insects at night. This is accounted for by the fact that in the daytime the light decomposes the gas into other gases, which, while being more hurtful to the trees, are not so fatal to the insects. Moreover the trees are more or less in a state of rest at night. Mr. Coquillett reports in full upon apparatus, methods, and preparations.

During the winter he carried on a series of experiments with washes against another very injurious scale insect, viz, the San José or pernicious scale (*Aspidiotus perniciosus* Comstock), using several substances heretofore not experimented with upon scale-insects, such as salt and water, salt and slacked lime, sulphur, corrosive sublimate, glue and aloes. The high price of the latter would debar its general use, but the results were exceptionally good. Of the substances experimented with the resin wash first introduced in Mr. Koebele's experiments for the Division was found to be one of the most efficacious as well as the cheapest.

Mr. Lawrence Bruner, the agent of the Division stationed at Lincoln, Nebraska, has investigated an outbreak of a local grasshopper—*Camnula pellucida*—which has for the past two or three years been appearing in numbers in parts of Idaho and Utah, but the greater part of his work has been connected with the collection and study of the insects injurious to the sugar beet, as the State of Nebraska has recently taken up the cultivation of this crop to a considerable extent. Mr. Bruner has found that no less than sixty-four different insects prey upon this crop at the present time, and the major part of his report is taken up with the enumeration of these species and comments upon them. The beet crop is an easy one to which to apply remedies, for, like the potato, the tops are valueless after a certain stage of growth and solutions so strong as to seriously injure them do not affect the root. Therefore, by a thorough use of arsenical solutions and strong kerosene emulsion the crop can be kept free from insects.

The report of our Indiana agent, Mr. F. M. Webster, on insects affecting cereal grains, relates largely to experiments and observations extending over a period of more than six years, to determine the number and development of broods of the Hessian fly. His observations and experiments have been made chiefly in the State of Indiana. He has found that the double-brooded habit of this insect, long ago pointed out by Dr. Fitch, holds true for ordinary seasons throughout Indiana. The fall brood in the southern portion of the State he finds to appear some weeks later than in the north and between the spring and fall broods retarded individuals of the one and accelerated individuals of the other brood appear, rendering the strict limitation of the other broods in some cases difficult, or giving the appearance of an intermediate third brood. The additional third brood, if it ever occurs, is certainly abnormal and unimportant, as shown by experiments carried out in the field and not subject to the vitiating influences of the breeding cage.

The usual time of appearance of the fall brood in southern Indiana

is from the last of September to the first of October, so that to escape the attacks of the fly wheat in this region should be sown soon after the first of October.

In the northern half of Indiana the flies appear from two to three weeks earlier, and experience has practically indicated that in this part of the State wheat sown between the 15th and 25th of September is the most likely to escape the attacks of the Hessian fly.

The later appearance southward of the fall brood has been noted by all observers. Mr. Webster's experiments give more accurate information as to dates of appearance of the flies and, therefore, of the best time for seeding in the region under study and will be of great practical value to the Indiana farmer. His conclusions will also apply to a large part of our wheat belt.

The report on this insect also includes some interesting observations on the effect of the larva on the plants, particularly in the matter of color, of the effect of the weather on the development of the fall brood, and concludes with a review of the preventive and remedial measures.

The report further contains a brief account of the European grain Toxoptera (*T. graminum*), which during the last few years has been very abundant in certain sections in the West and Southwest, and which we instructed Mr. Webster early in the year to carefully investigate. Our knowledge of this recently imported grain pest is still far from complete, although the season's observations have added considerably thereto.

A short report on the grain aphis (*Siphonophora avenæ*), supplementary to our article in the Annual Report of the Secretary of Agriculture for last year, is given, and also brief accounts of the apple plant-louse (*Aphis mali*) on small grains, a new species of *Diplosis* and the twelve-spotted *Diabrotica*, of which latter unmistakable larvæ were found eating into the stems of young wheat.

The principal work reported upon by Mr. Albert Koebele, the agent at Alameda, California, is a series of experiments which he has carried on chiefly during the month of September in the Sonoma Valley to ascertain the effect upon the grape Phylloxera of certain of the resin washes which proved so valuable when used against the fluted scale. The results have been quite as good as we anticipated and the experiments have shown that in the use of these washes we have a most valuable addition to the remedies for this great pest.

The formula which gave most satisfaction is as follows:

Caustic soda (77 per cent)	pounds..	5
Resin	do ..	40
Water to make 50 gallons.		

The soda should be dissolved over a fire in 4 gallons of water, then the resin should be added and dissolved. After this the required water can be added slowly while boiling to make the 50 gallons of the compound. To this water may be added at the rate of 9 gallons for 1, making 500 gallons of the dilute compound, sufficient for one hundred large vines, at a cost of only 84 cents, or less than a cent a vine.

In addition to this work Mr. Koebele has studied the tent caterpillars of the genus *Clisiocampa* of the Pacific coast and has done some extensive collecting and breeding of fruit tree and garden pests in that section of the country. He has also done some excellent work in the study of parasites of the codling moth and of other injurious insects.

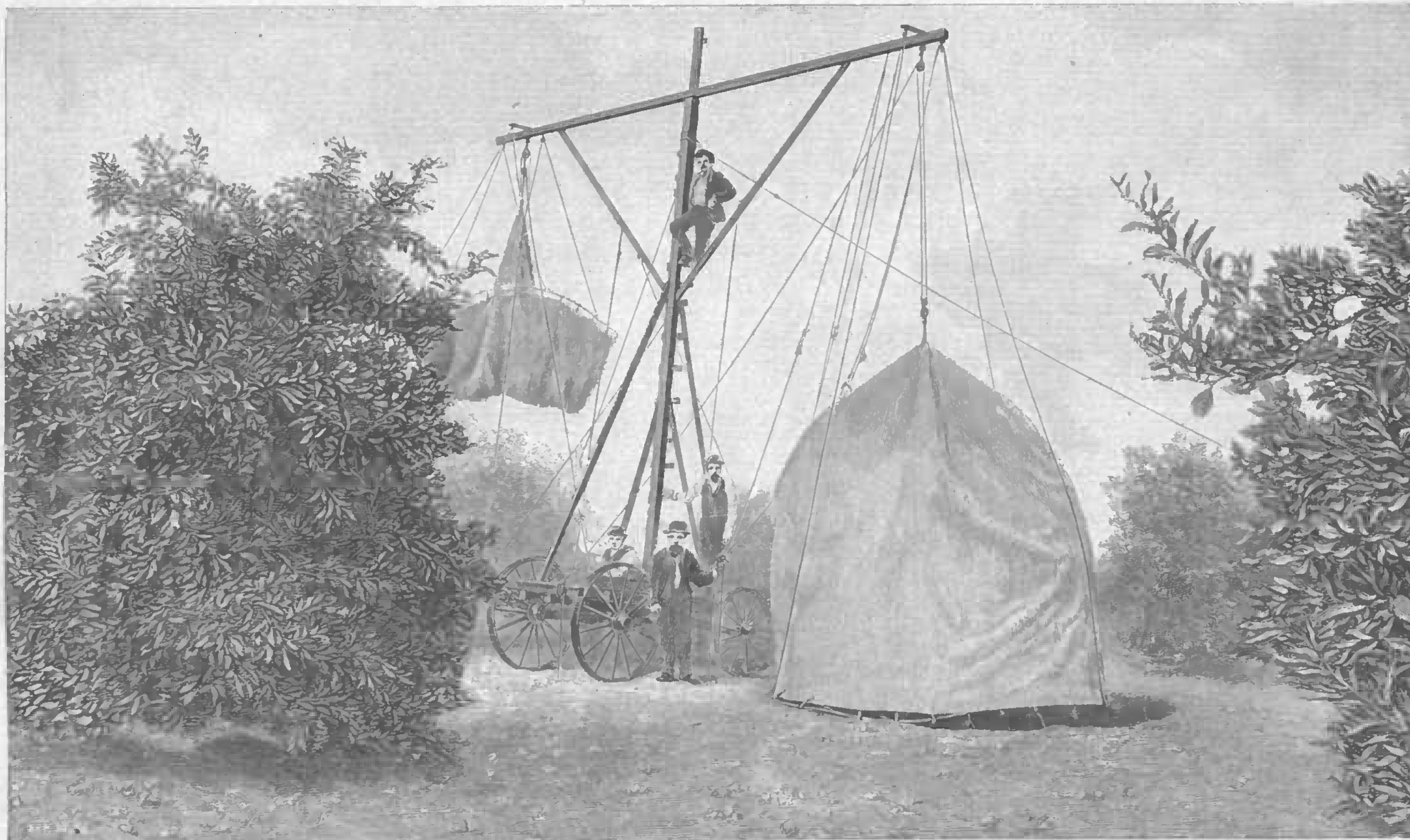
Miss Mary E. Murtfeldt divides her report into three sections: (1) general observations, (2) a few more injurious Microlepidoptera on apple, and (3) experiments with insecticides. Under the first head she gives a general account of the injurious insects of the season in Missouri, calling attention to the comparative immunity from the chinch bug, the canker worm, and cut-worms. The stalk borer (*Gortyna nitela*) and the corn ear-worm (*Heliothis armigera*) were particularly abundant, while the slug caterpillars or stinging caterpillars (family *Cochliopodidæ*) were noticed in unusual numbers. All through Missouri and adjoining States there was a notable outbreak of the walnut, hickory, and oak caterpillars (*Datana ministra* and *D. angusii*). One of the most interesting observations made by this agent was to the effect that the fall web-worm (*Hyphantria cunea*) was extensively preyed upon in Missouri this summer by the larvæ of a Carabid beetle, *Plochionus timidus*.

In the second section of her report she considers four new apple enemies: *Penthina chionosema*, *Proteopteryx spoliana*, *Steganoptycha* sp., and *Gelechia intermediella*. Under the head of experiments with insecticides are given accounts of experiments with X. O. dust, buhach, arsenites of ammonia, and petroleum sludge. It was found that dry X. O. dust blown from a bellows during the middle of the day is a thoroughly satisfactory remedy for plant-lice of all kinds. The arsenites of ammonia when used according to the manufacturer's directions, one tablespoonful to a gallon of water, proved to be an efficient insecticide, but badly scorched the leaves of peach and cherry, and damaged slightly the foliage of plum, apple, rose, and squash. The petroleum sludge arrived too late for satisfactory trial, but Miss Murtfeldt thinks that its intolerable and persistent odor is a serious obstacle to its general use, especially in small gardens.

The Iowa agent, Professor Osborn, has continued his work on the parasites of domestic animals and has submitted for publication in bulletin form that portion which relates to the Mallophaga. He has continued his observations on insects injurious to pasturage, a subject which received treatment in his report for 1889 (published in Bulletin No. 22 of the Division), and reports upon additional species of importance in this direction. He has also reported upon the insects of the season in Iowa, mentioning among others two pests new to the State, viz: Abbott's white pine worm (*Lophyrus abbottii*) and the potato stalk-borer (*Trichobaris trinotatus*). Some remedial experiments were also reported. He has found that in Iowa the arsenites of ammonia in the customary dilution do not injure the foliage of squash, cucumber, potato, plum, cherry, box elder, willow, eleagnus, elm, mountain ash, birch, apple, raspberry, bean, grass, and clover, while his experiments seem to show that it is as effectual as an insecticide as the more generally used Paris green and London purple.

Report of the Entomologist, U. S. Department of Agriculture, 1890.

PLATE II.



THE LEEFELD FUMIGATOR.

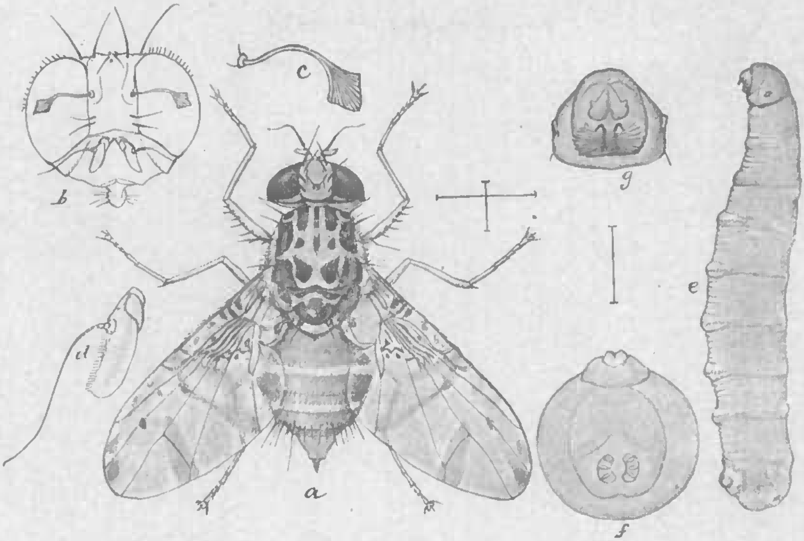


Fig. 1.

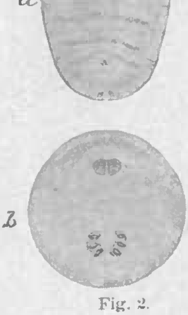


Fig. 2.

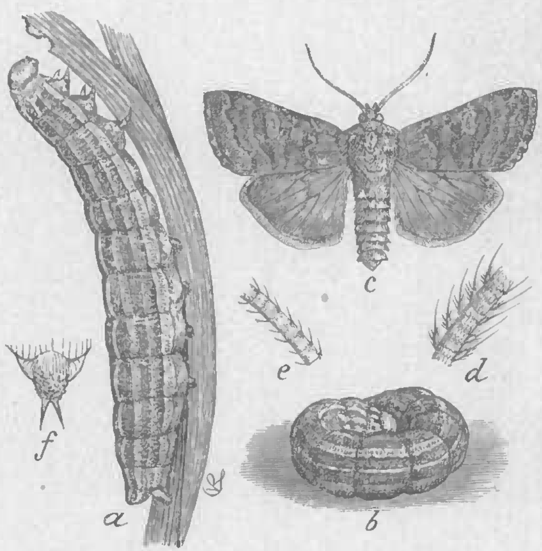


Fig. 3.

CERATITIS CAPITATA AND NEPHELODES VIOLANS.

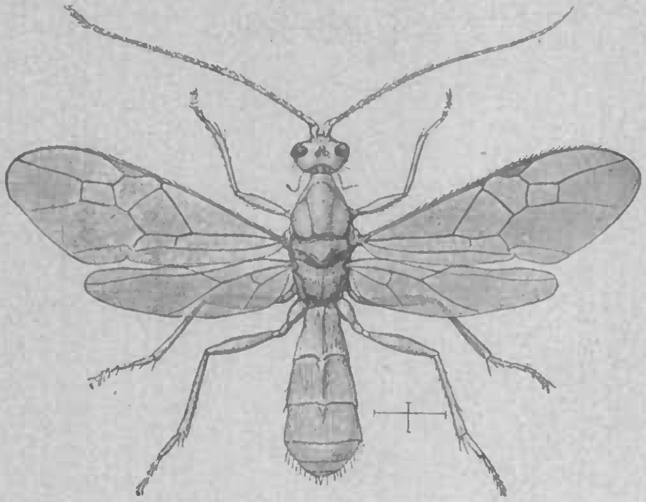


Fig. 1.

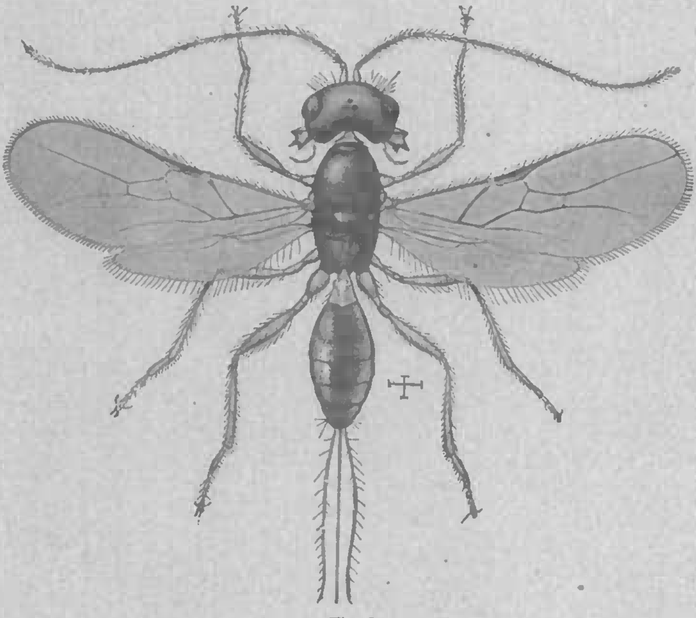
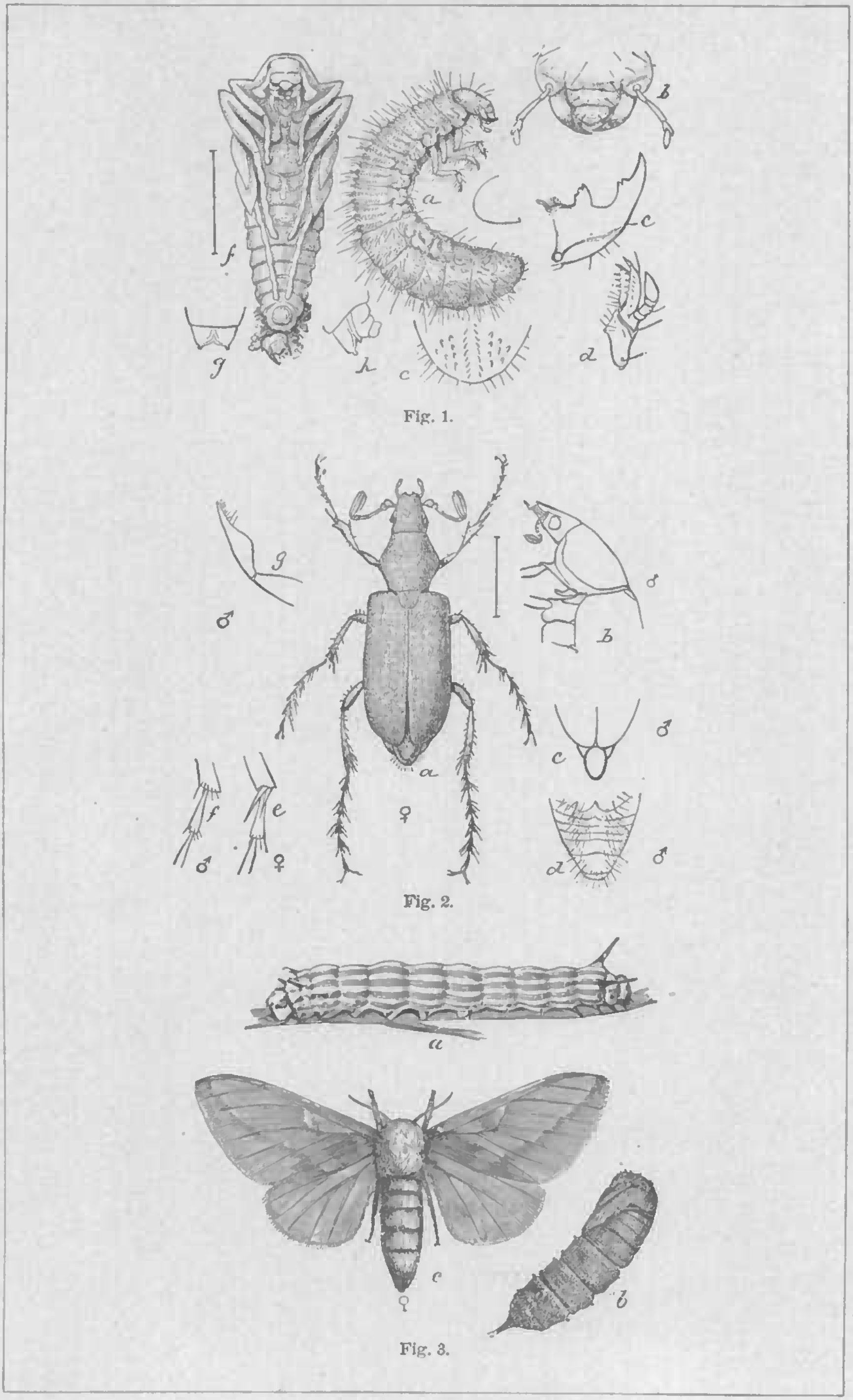


Fig. 2.

PARASITES OF NEPHELODES AND HÆMATOBIA.



THE ROSE CHAFER AND THE GREEN-STRIPED MAPLE WORM.

THE STATE CAPITOL AT LINCOLN, NEBRASKA, SHOWING TREES DEFOLIATED BY THE GREEN-STRIPED MAPLE WORM.

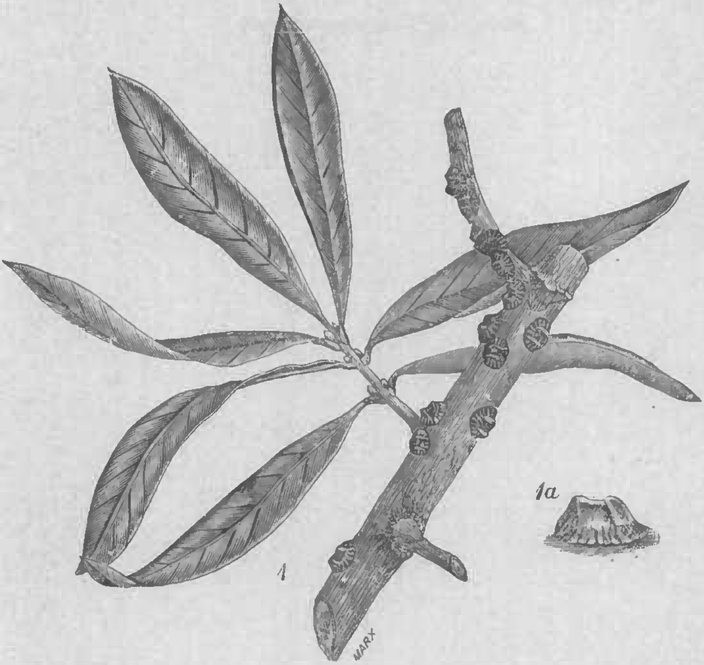


Fig. 1.

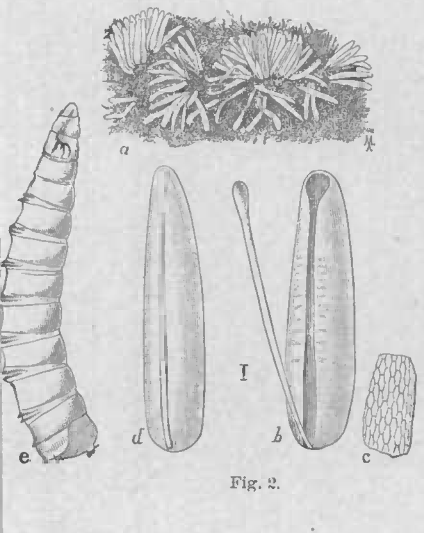


Fig. 2.

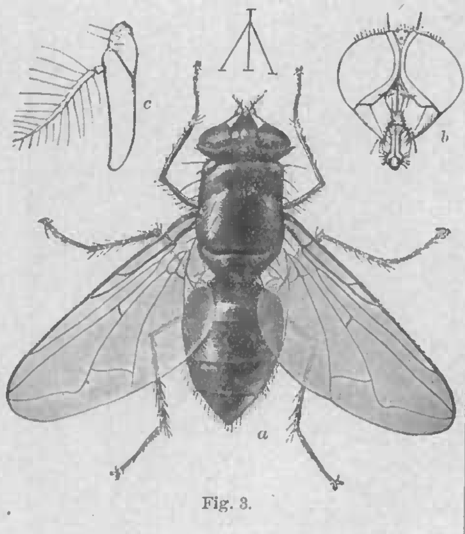


Fig. 3.

THE BLACK SCALE AND LUCILIA CÆSAR.

REPORT OF THE CHIEF OF THE SILK SECTION.

SIR: I have the honor to hand you herewith my second annual report as Chief of the Silk Section. The staff, clerical and operative, has remained as last year, though the correspondence has largely increased, 9,878 letters having been received during the calendar year 1890, as against 5,448 reported for 1889. The scope of the work of the Section has not greatly changed, as will be seen from the report which follows.

Yours respectfully,

PHILIP WALKER,
Chief of the Silk Section.

HON. J. M. RUSK,
Secretary.

AUTOMATIC SILK REELS.

My report of a year ago told of our work in the direction of perfecting an automatic machine for the reeling of silk, and said that while I believed that substantial progress had been made, still no conclusive results had been reached. I also gave an account of the improvements in preparatory machinery made by Mr. Serrell, in France, and of his temporary abandonment of his experiments for the production of a machine for automatically reeling the silk, properly speaking. I can not learn that his course of action has been changed during the past year. The exhaustion of our funds led me, too, to abandon my mechanical experiments last spring and they have not been renewed during the present fiscal year. The growing conviction that, with existing machinery, silk reeling could be made profitable, if such legislative assistance as has been asked of Congress were accorded, led me to recommend to the Assistant Secretary the temporary suspension of such experiments, and such suspension was authorized by him. It is felt that the establishment of silk reeling in the United States, which we feel sure would follow the legislation mentioned, would soon draw the attention of inventors to this matter, and it seems highly probable that the desired result will, if such circumstances exist, some day be attained and an automatic silk reel be perfected in time to supply any commercial demand that may arise for it.

PROPOSED LEGISLATION FOR THE ENCOURAGEMENT OF SILK CULTURE.

During the last session of Congress, while the Committee on Ways and Means was engaged in the taking of testimony concerning the many industries which the proposed tariff bill would affect, I was instructed by you, at the request of the chairman of the committee, to appear before it and explain the relations which the raising and reeling of silk bear to the more advanced branches of manufacture concerned in the production of this textile. In accordance with these instructions I presented myself at the Capitol on the 6th of January and submitted the facts that I had in my possession. At the request of the committee I again appeared before it early in March to reply to some objections to my suggestions that had been raised by the officers of the Silk Association of America. My remarks on these occasions were published in the report of the evidence taken by the committee (pages 601 and 1349).

My suggestion was that the committee should recommend a duty of $1 per pound on reeled silk imported into the United States. I then believed, as I do now, that such a duty would make it possible to conduct the industry of silk reeling, with profit, in the United States. The representatives of the manufacturers opposed this suggestion most strenuously, saying: First, that silk culture was climatically impossible in our country; second, that neither the duty which I suggested nor any other which I could with any reason expect to have ingrafted in the bill, would make it possible to reel silk with a profit in the United States; and third, that if the duty upon reeled silk which I proposed were levied, it would ruin the interests vested in the manufacture of silk in this country and, in a very short time, close all the mills.

The first assumption I refuted from the published books of the Silk Association itself, and I endeavored to persuade the committee, and I think with success, that I was in quite as good a position to judge of the result of any given protection as a body of gentlemen who made no pretensions to being experts in the industry of silk reeling, and who were confessedly opposed to its establishment in our country. Their third objection, however, that it would ruin the manufacturers, was one which had more effect upon the committee and, while it seems to me that it was as little founded on fact as the other two, I was unable to counteract the impression which it evidently made.

I therefore suggested that, in place of a customs duty, the committee should recommend the granting of a bounty of $1 per pound upon reeled silk produced in the United States from cocoons of American production, and an additional bounty of 7 cents per pound for fresh cocoons of domestic growth. The suggestion was adopted and incorporated in the tariff bill and with it was passed by the House. The Senate Committee on Finance, however, reported adversely upon the section and recommended that it be stricken out, which was done, nor was it restored in conference.

During the past session a bill for the development and encouragement of silk culture in the United States was introduced both in the House (H. R. 137, by Mr. Morrow) and in the Senate (S. 1426, by Senator Mitchell) at the instance of Mr. Joseph Neumann, of California. This bill creates a division of silk culture in this Department and defines the duties of the Secretary of Agriculture in con-

nection therewith. Most important of these duties are the payment of bounties on reeled silk and cocoons produced in the United States and the establishment of sericultural experiment stations for the education of the people in the industries of silk raising and silk reeling and for similar purposes. Another bill (H. R. 8675) was introduced later in the session by Mr. McKenna for the encouragement of silk culture in the State of California. It proposed nothing that would not be included in an intelligent execution of the Neumann bill.

I am heartily in favor of the enactment of some measure which will embody the main features mentioned above. This measure was, you will recollect, referred to you for your opinion by the agricultural committees of the two Houses of Congress, and on your suggesting that it was perhaps inexpedient to report upon it pending action upon the revenue legislation which I have already mentioned, it was, I understand, temporarily laid aside. I now most respectfully and urgently recommend that the committees of the House and Senate be requested to take the matter into further consideration, and after suitable amendment to recommend favorable action upon the bill.

The passage of some measure which shall give a permanent and sure encouragement to silk reelers and growers is, in my estimation, a *sine qua non* to the establishment of silk growing in the United States. After carefully considering the matter I am of the opinion that better results can be obtained by the payment of a bounty for a period of, say ten years, than by the imposition of any duty, however large, upon the manufactured material. The disposition shown by Congress to grant bounties, as evidenced in the case of the sugar industry, will, I hope, lead that body to a favorable consideration of this suggestion now that the question, as applied to the silk industry, is freed from the entanglement of being embodied in a general tariff bill.

Feeling as I do the importance of such legislation to the future of silk culture, and the probability that a failure upon the part of Congress to enact it would be very detrimental to the interests of silk raisers, I deem it proper to present, in as few words as possible, a summary of those reasons which have led me to the belief that under suitable conditions this industry might be made profitable in our country. It has many times been stated in our reports that the inadvisability of attempting silk culture on a large scale had been established for years by the disastrous results of experiments of this nature in France and Italy. The average quantity of eggs placed in incubation in those countries is now about two ounces for each family. Under such circumstances the European farmer is not called upon to employ extra labor, nor are the services of the men of the family required except during the last few days of the rearing. It will be understood that the confining of this work to the women and children necessitates the planting of the mulberry trees in a convenient place near the house, their periodical pruning in such a shape that their leaves can be gathered economically and quickly, and a further condition, perhaps axiomatic, that the persons in charge of the work shall possess such experience as will enable them to perform their labors without serious mistakes or useless friction. It would be an imputation which I should be far from placing upon the women of our farming classes to suggest that they are not as able as their sisters in Europe to become expert silk raisers in a short time.

The work of silk raising occupies from five to six weeks in the spring of the year, beginning upon the budding of the leaves and ending, almost everywhere in this country, before the 1st of July. The labor during the first three weeks of this time is light and it is only during the last age of the worm that the care required becomes constant and the toil fatiguing. An experienced woman, with food at hand in suitable quantities, can easily rear the product of one ounce of silk-worm eggs, with two or three children to pick leaves for her. As I have stated before, assistance might be required of the male portion of the family during the few days prior to the spinning, when the appetite of the worms becomes almost ravenous.

While the natural food of the silk-worm (the mulberry tree) has been planted in comparatively small quantities in the United States, it is a tree of rapid growth and in four years from the seed it can safely be denuded of its leaves without injury to its vitality. It may be planted along the fence lines and thus occupy ground that is so rarely utilized by American farmers. By inquiry I find that the nurserymen, particularly of the West, have large numbers of these trees in stock, which they hold at extremely low prices. In the meantime, while trees are growing, several of our States have an abundant supply of osage orange, the suitability of which to silk raising has long been acknowledged.

We have, then, an industry offered to us which should only be encouraged as one subordinate to the household duties of the women of our farming classes, and from which each should be able to derive a small addition to her annual income by work which lasts but little over a month and which is tedious during a period of not more than ten days. As a return for this labor a woman should harvest not less than 80 pounds of cocoons per ounce of eggs; cocoons which are now worth in the neighborhood of 35 cents per pound (fresh). While she could thus obtain nearly $30 for her otherwise unremunerated labor from the rearing of an ounce of eggs, this amount, by the application of more energy and the assistance of a larger family, might easily be doubled or even trebled by undertaking a larger crop and still without passing the bounds of possibility. This sum in itself may to some seem a small inducement for undertaking the work, but such is not the opinion of those who have become sufficiently expert to be justified in reaching a conclusion and who know the amount of labor involved. It is by its multiplication throughout the innumerable families which would be engaged in the industry, if we produced all of the reeled silk which we consume, that we should add immensely to the aggregate income of the farming classes of the United States.

In my report of a year ago I gave a summary of the total consumption of reeled silk in Europe and the United States, and showed that we were using about one fifth of that consumption in our own country. Our importations had been rapidly increasing in previous years, so that for the fiscal year ending June 30, 1889, we imported "unmanufactured silk" to the value of $19,333,229. The report of the Bureau of Statistics for the present year shows the remarkable increase in this importation of 25 per cent of the entries for 1889, the purchases for the year ending June 30, 1890, having reached $24,331,867.*

*Reeled silk, $23,285,099; waste, $951,910; cocoons, $88,522; silk-worm eggs, $6,336.

About 87 per cent of the value of reeled silk is the worth of the cocoons from which it is produced, and it therefore cost the reelers of the silk imported by us during the last year more than $20,000,000 for the cocoons consumed by them. These cocoons would have been purchased from the farmers, and this amount would have been added to our aggregate agricultural income, had we produced our raw silk instead of buying it of foreign nations.

While the introduction of silk culture into the United States would, like that of any other industry, necessarily be slow, the object to be attained is so great that we should look ahead a decade or two to fully understand its import. The importations of reeled silk into the United States have increased, since 1870, from 583,589 pounds to 5,943,360 pounds, or from a value of $3,017,958 to $23,285,099. This is an increase of more than 900 per cent in weight and 670 per cent in value. The growth has been steady, healthy, and I think I am safe in saying without precedent in any other industry. There is no reason to believe that that growth will not continue to be as phenomenal in the next ten years. I showed in my last report that the consumption of reeled silk by the Western world from 1884 to 1888 increased but 18 per cent, while our own importations increased 60 per cent. If this continues we shall, before many years, be using as much reeled silk as Europe, and, unless our neighbors across the sea reduce their home consumption, our own manufacturers will need to seek new sources of supply. The average declared value of our imports of reeled silk in 1888–'89 was $3.48 per pound and in 1889–'90, $3.90, an increase of 12 per cent, due almost entirely to the short cocoon crop of 1889 in France and Italy. Such being the outlook it seems a penny-wise pound-foolish policy for silk manufacturers not to heartily favor instead of to oppose the proposed bounties; and such persons as may assist, though hesitatingly, in their establishment, will, I feel convinced, find after a lapse of years that they builded better than they knew.

DISTRIBUTION OF SILK-WORM EGGS.

During the season of 1890 there were distributed in forty-two States and Territories 800 ounces of eggs, divided into 2,250 lots, an increase of 979. The distribution was as follows:

State or Territory.	Lots.	State or Territory.	Lots.
Alabama	30	Missouri	211
Arizona	4	Nebraska	60
Arkansas	31	New Hampshire	1
California	47	New Jersey	47
Colorado	5	New Mexico	4
Connecticut	15	New York	88
Delaware	10	North Carolina	71
District of Columbia	20	Ohio	177
Florida	55	Oregon	1
Georgia	31	Pennsylvania	154
Illinois	166	Rhode Island	3
Indiana	89	South Carolina	21
Indian Territory	23	South Dakota	10
Iowa	59	Tennessee	25
Kansas	306	Texas	54
Kentucky	32	Utah	12
Louisiana	24	Vermont	3
Maine	1	Virginia	123
Maryland	75	West Virginia	29
Massachusetts	30	Wisconsin	15
Michigan	47		
Minnesota	14	Total	2,250
Mississippi	27		

The distribution comprised the following varieties:

	Ounces.
French:	
Deydier (Cevennes race)	200
Ribaud l'Ange and Gorde (Lower Alps race)	100
Aubin (improved Var race)	100
Forné (Pyrenees race)	100
Italian:	
Mercolini (Marches race)	100
Pucci (Umbrian race)	100
Mari (Ascoli race, two varieties, B and P)	100

Of the Deydier (Cevennes) eggs we can say nothing favorable They were a failure in the hands of even the most careful raisers, and this year this house has been left out in placing our orders. The greater part of our eggs were placed in quarter ounces and in such small lots should have given at least 100 pounds of fresh cocoons per ounce. As a matter of fact there were many raisers who did much better than that, as shown by the following table, but I regret to be obliged to add that it also shows that the average for every race was far below that figure.

Race.	Average crop per quarter ounce.		Largest crop per quarter ounce.	
	Lbs.	*Oz.*	*Lbs.*	*Oz.*
Alps	12	4	35	8
Var	12	0	25	8
Pyrenees	13	2	35	4
Marches	11	4	30	0
Umbrian	11	9	30	6
Ascoli B	9	3	25	2
Ascoli P	10	4	21	0

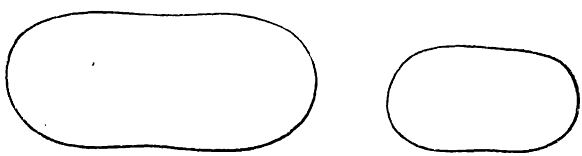
As will be seen from this table the best lot of coccons raised from Umbrian eggs weighed 30 pounds and 6 ounces fresh, which means more than 120 pounds for the ounce of eggs. Such a result is not at all astonishing, and by reference to my report of a year ago it will be seen that it was not as good by 4 pounds to the quarter ounce as we then obtained in our own rearing. It is, however, too much to expect persons with ordinary rearing facilities to make as good a crop as is made in a rearing room that has been prepared with all due regard to ventilation, and where expense has not been spared to make it satisfactory from that point of view. But there is no reason why any silk raiser can not obtain a rendition of 80 pounds of fresh cocoons per ounce, if due care is exercised in following the necessary elementary rules of practical silk growing. Out of the eighty-seven raisers of one-quarter-ounce lots of Umbrian eggs from whom we have received reports, only eight raised more than 20 pounds of cocoons, and I do not scruple to say that insomuch as any raiser fell short of this amount in the total weight of his crop, to that same degree he failed to get the results which he and we had a right to expect from such eggs as were furnished him. What I have said of these Umbrian eggs is equally true of all the other eggs distributed, except the Cevennes.

As has been shown by the table on page 269, 2,250 lots of eggs were distributed last season. This was far in excess of the distribution of 1889 and more than double that of 1888, as shown in former

reports. It is a fact much to be regretted that almost everyone of these applicants had never before applied to us for silk-worm eggs, and, judging from past experience, are not likely to again. Of the upwards of 1,000 raisers who were furnished with eggs in 1889, a little less than 10 per cent had also been applicants in 1888, and of the 2,200 who applied in 1890 but 62 had ever asked us for a similar provision in previous years. Twenty-two of those were supplied in all three of the seasons mentioned.

All of these persons were requested to make some sort of a report to the Department of the result of their work, and all were informed that the Department would purchase their cocoons at a reasonable price. Notwithstanding this, we have received lots from but about 30 per cent of those persons to whom we furnished one quarter of an ounce of eggs. Allowing for the sales to the Kansas State commissioner and other purchasers, it is safe to say that half of the raisers made such complete failures that they had nothing to report upon and nothing to sell.

An examination of the lots received from these small raisers shows us also the difficulty of teaching them the work by the distribution of printed matter. Our pamphlets have been prepared in accordance with the methods adopted by the best silk raisers of Europe, and whenever our experience has shown them to be deficient in certain points, we have upon the printing of a new edition endeavored to bring them more into accord with the needs of our people. One of the points we have called attention to with an especial emphasis is the necessity of feeding the worms liberally and regularly, and still, of the lots which we have received, many show unmistakable evidence of underfeeding and neglect. This is most distinctly emphasized when we receive a lot of cocoons from one raiser which will average as large as Fig. A, annexed, while another raiser, with no more experience and with eggs from the same lot, sends in others of the size indicated in Fig. B.



A B

To the more successful one we pay about 35 cents per pound of fresh cocoons, but the failure is well compensated at 20 cents per pound. It is scarcely necessary to point out the fact that poor quality and consequent low price are almost always the companions of light weight in the crop, so that side by side we have a person who realizes $10 from the cocoons produced from a quarter ounce of eggs, and another who realizes less than $1. In fact we have on several occasions paid less than 10 cents for the cocoons raised by such a grower. All of this emphasizes the fact that if silk culture is to be established in the United States it is absolutely necessary that means should be taken to come into actual contact with our people in order to teach them to raise silk-worms successfully. There seems to be no better way than by the establishment of such stations as are contemplated in the legislative measures that have already been dis-

cussed. Far more general good can be accomplished by the establishment of a few model rearing rooms, where silk-worms can be properly raised every season, in the full view of everybody who chooses to examine into the industry. Thus might be created several centers from which the industry could be spread over such portions of the country as are climatically adapted to it. At present far more harm is being accomplished by assisting would-be silk raisers to make inevitable failures and thus augmenting the number of persons who believe, beyond all power of persuasion, that silk culture is a delusion and a snare for the unwary agriculturalist.

It is not, however, to underfeeding that we must attribute all of the failures that I must report; nor always can it be laid to the door of that inexperience which, I hope, time will correct. All over the South the frosts of the early spring killed the already budding mulberry leaves and much loss has been reported from eggs prematurely hatched before the new growth appeared.

Disease has also made ravages among the silk-worms and much loss is due to this cause. Pébrine has practically been blotted out, and of it and muscardine, again common in Europe, we hear nothing here. The evil comes from flaccidity and, this year, grasserie above all, maladies which are generally attributable to carelessness in some step of the work, in the preparing or caring for the eggs or rearing the worms; but which too often come to the most careful, owing to bad meteorological conditions. Grasserie, which usually attacks but a few worms in a brood, and which, because it is generally unattended by other diseases, is welcomed by Europeans as a harbinger of a good crop, has this year carried off whole broods. This, too, was the case in this Department with the worms fed on osage orange in 1889. An examination of the reports of those who have informed us of the prevalence of this malady does not show that it was common among worms of any particular race, or due to the feeding of any particular food.

THE COCOON CROP OF 1890.

So far as we have been able to ascertain, the following quantities of fresh cocoons were produced in the different States and Territories and purchased at the stations mentioned. Six hundred and eighty-nine lots were purchased at Washington, averaging 16 pounds, and for them we paid an average of 29.6 cents per pound, fresh (about 89 cents per pound, dry).

State or Territory.	Washington.		Philadelphia.		Peabody.		Total.	
	Lbs.	*Oz.*	*Lbs.*	*Oz.*	*Lbs.*	*Oz.*	*Lbs.*	*Oz.*
Alabama	68	4					68	4
Arkansas				3				[illegible]
California	786	0	61	6			847	[illegible]
Connecticut	50	8	5	0			55	[illegible]
Delaware	67	2	68	3			135	[illegible]
District of Columbia	94	10					94	[illegible]
Florida	30	0	204	8			234	[illegible]
Georgia	92	1					92	[illegible]
Illinois	915	5	111	8			1,026	[illegible]
Indiana	437	10	161	11			599	[illegible]
Indian Territory	1	8					1	[illegible]
Iowa	265	2	18	9			283	[illegible]
Kansas	713	10	24	7	3,000	0	3,738	[illegible]
Kentucky	114	6					114	[illegible]

State or Territory.	Washington. Lbs.	Oz.	Philadelphia. Lbs.	Oz.	Peabody. Lbs.	Oz.	Total. Lbs.	Oz.
Louisiana	22	8	7	9			30	1
Maryland	201	0	67	6			268	6
Massachusetts	141	12	2	7			144	3
Michigan	199	2	109	10			308	12
Minnesota	113	4					113	4
Mississippi	178	11					178	11
Missouri	1,573	14	1,587	13			3,161	11
Nebraska	433	12	1	15			435	11
New Jersey	87	6	3	11			91	1
New York	134	4	30	12			165	0
North Carolina	302	7					302	7
Ohio	1,421	10	280	5			1,701	15
Oregon	12	12					12	12
Pennsylvania	395	4	332	2			727	6
Rhode Island	14	0					14	0
South Carolina	28	14	12	2			41	0
South Dakota	93	2					93	2
Tennessee	72	0					72	0
Texas	339	12	6	15			346	11
Utah	890	7					890	7
Vermont	9	0					9	0
Virginia	378	2	19	3			397	5
West Virginia	60	12	17	9			78	5
Wisconsin	44	4	35	1			79	5
Total	10,784	0	3,169	15	3,000	0	16,953	15

VARIETIES OF COCOONS.

Greatly to my regret, a failure to prepare the illustrations in time, prevented my inserting in my annual report for 1889 an account of some of the typical races of cocoons raised in Europe. As I there stated the great bulk of French eggs is produced in the department of the Var. The typical race of that department is large and of coarse texture (Plate I, Fig. 1), more so in fact than is found profitable by silk reelers who prefer to go to neither extreme, either in size or texture. As a result this race has largely been used in crossing. In the Oriental Pyrenees we find the small, fine Roussillon race (Plate I, Fig. 3), also rarely reared commercially. The crossing of these two, however, produces a robust, healthy variety, of good rendition and pleasing to the reelers. It is shown at Plate I, Fig. 2, between the other two, so as to be easy of comparison.

The improvement of races is also frequently accomplished by a change of climate. Such a change has produced from the coarser Var a cocoon like that shown at Plate II, Fig. 1, when reproduced in the Oriental Pyrenees. The Cevennes race, again, is of the desired mean, both in size and texture. It is shown at Plate II, Fig. 2. The effect of climate is perhaps most strongly shown in the white Bagdad cocoons illustrated at Plate III, Figs. 3 and 4. The former was obtained from M. Marcy, of Grasse, Var, and had been raised by him but one season since the arrival of the original eggs from the Levant. The race shown in Fig. 4 had been several times reproduced in France, though of the same origin as the first mentioned. It will be seen how a change of climate and careful selection have toned down the rugosity of its surface and brought its shape to that more ordinarily found among European races.

Early in the spring, long before the mulberry leaves were budded in Washington, there reached us through the State Department, from the consul general at Teheran, two lots of silk-worm eggs, already hatching. They had been obtained by him from Sabzawar (Persia) and Herat (Afghanistan). They were raised as well as possible, first on lettuce, and later on mulberry leaves, received daily by mail from Florida. They did fairly well under the circumstances, the two races showing no difference in the cocoons. These were in each case deep yellow and white mixed and were covered with a large quantity of floss. The sizes of the cocoon with and without floss are so different that I have thought it interesting to show them. They are illustrated at figures 1 and 2 of Plate III. The pointed ends, it will be noticed, are in great contrast with the ordinary rounded cocoon of Europe.

A few years ago there were obtained by M. Natalis Rondot, from Persia, two races called the Shazevar, green and yellow. M. Rondot considers them, as nearly as possible, the primitive races of the country, as are the White Cina of China. When received they showed a good deal of pébrine, and in fact eggs of this race that we obtained in 1889 from Padua did not give a single cocoon. We were more successful, however, in 1890, receiving a pinch each of yellow and of green eggs which did excellently. The cocoons are very large, as shown in Plate II, Fig. 3. We have saved some healthy eggs of each race and made some experiments in crossing, upon which I shall report next year.

Another type of cocoon is shown at Plate III, Fig. 5. It is of Cyprian origin, raised one year in Italy and one in Washington. The cocoons are proportionately longer than most well-known races, pointed at the end and of rather coarse texture.

All of the cocoons shown are of the natural size.

THE PRUNING OF MULBERRY TREES.

In my annual report for 1887 I described the process of raising mulberry trees as practiced in the Cattaneo nurseries, in Italy. It will be seen from that account and from the two plates which accompany it, that the tree described is one of the kind called "standard," that is to say that it is allowed to branch at a point 6 feet from the ground. The main object of cultivating a tree as high as this is to permit of another crop being planted in the orchard, and it is customary in Italy so to plant corn or wheat, leaving a passage along each row of trees so that the leaves can be picked without injuring the surrounding grain. The picking of leaves from a tree like this requires the use of a double ladder, and this, among American women, will alone operate to the disadvantage of this style of pruning.

We have, on the Department grounds, a row of dwarf mulberry trees such as is shown in Plate IV of this report. The tree there shown was first made to fork at 1 foot from the ground, a second time at about 6 inches higher, and still a third time 6 inches higher yet. It will require but one more "crowning," as this pruning is called, to get the tree into proper shape; then all that will be necessary will be to cut back the shoots once in two years in order to obtain a suitable supply of leaves. As the tree was photographed its foliage (Fig. 2) weighed 6 pounds. It was 7 feet high and 8 feet across the branches. To allow for suitable growth these trees should be

planted about 10 feet apart and make an excellent form for setting along a fence line.

Another manner of pruning is shown in Plates IV and V, copied from photographs of a half-standard tree. This tree is of the same age as the other but has been pruned but twice. It is 3 feet from the ground to the lower fork, and, as was the case with the dwarf, 6 inches more to the upper one. The tree was 7 feet across and 9 feet high and might be planted in the same manner as the other. It furnished 14 pounds of leaves.

It may be well to add that the foliage of both of these trees will probably be three times as great next year as it was last, and further, that the trees were of the seedling white variety (*Morus alba*), of which the leaves are small and much indented. A rose mulberry tree of the same age and size would probably furnish more than twice as great a weight of leaves, and these leaves in turn would give half as much more silk per hundred pounds as those of the seedling. Assuming these facts to be true, as they essentially are, rose mulberry trees of the form described above and at the age when they should be definitely formed (that is to say four years old) would give for the dwarf 36 pounds of leaves, and for the half-standard 84 pounds. From this it can be estimated how many trees would be necessary to furnish the foliage needed to feed the worms coming from an ounce of eggs, it being remembered that it takes 1,600 pounds for that purpose.

It will be recalled that these figures refer to four-year-old trees which are really about as small as are usually commercially employed. The trees grow rapidly from that age, and assuming the weight of leaves which such a tree will give to be 100 per cent, the quantity of foliage will augment, according to Gobin,* in somewhat the following ratio.

Age.	Per cent.	Age.	Per cent.
4 years old	100	14 years old	680
5 years old	157	15 years old	741
6 years old	225	16 years old	777
7 years old	287	17 years old	805
8 years old	373	18 years old	827
9 years old	423	19 years old	846
10 years old	463	20 years old	861
11 years old	566	21 years old	868
12 years old	605	22 years old	877
13 years old	658		

* Muriers et Vers à Soie, Paris, 1874, p. 93.

DESCRIPTIONS OF PLATES.

PLATE I,	Fig. 1.	Cocoons of the large Var race (France).
	Fig. 2.	Cocoons of Var crossed with Roussillon.
	Fig. 3.	Cocoons of the Rousillon race (France).
PLATE II,	Fig. 1.	Cocoons of the Var race reproduced in the Oriental Pyrenees (France).
	Fig. 2.	Cocoons of the Cevennes race (France).
	Fig. 3.	Cocoons of the yellow Shazevar race (Persia).
PLATE III,	Fig. 1.	Cocoons of the Sabzewar race (Persia) with floss.
	Fig. 2.	The same with the floss removed.
	Fig. 3.	Cocoons of the white Bagdad race raised one season in France.
	Fig. 4.	The same raised several seasons in France.
	Fig. 5.	Cocoon of a race from Cyprus, raised one season in Italy and one in Washington.
PLATE IV,	Fig. 1.	Half-standard mulberry tree before pruning.
	Fig. 2.	The same after pruning.
PLATE V,	——	Half-standard mulberry tree with foliage.
PLATE VI,	Fig. 1.	Dwarf mulberry tree with foliage.
	Fig. 2.	The same without foliage and before pruning.
	Fig. 3.	The same after pruning.

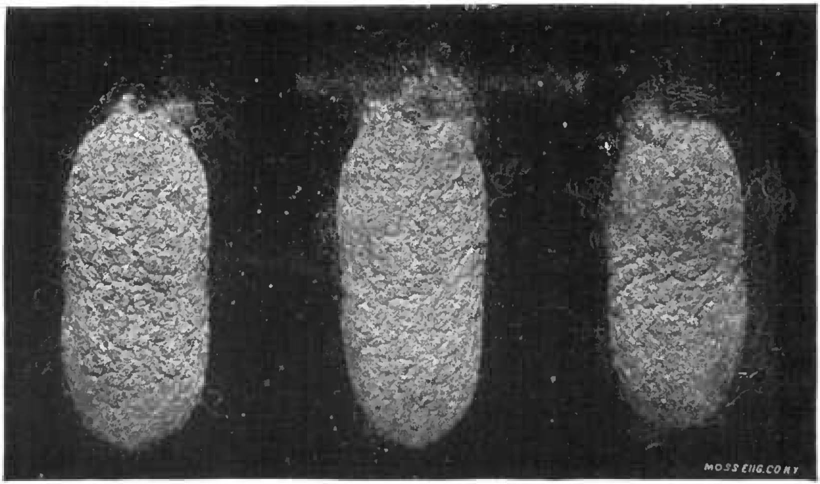


Fig. 1. LARGE VAR.

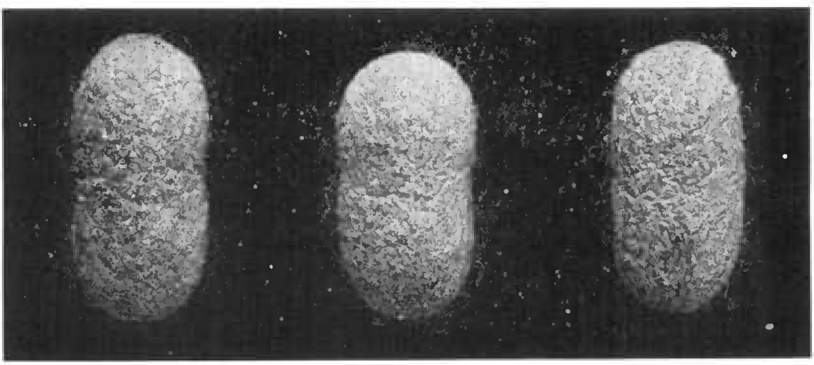


Fig. 2. VAR AND ROUSILLON CROSSED.

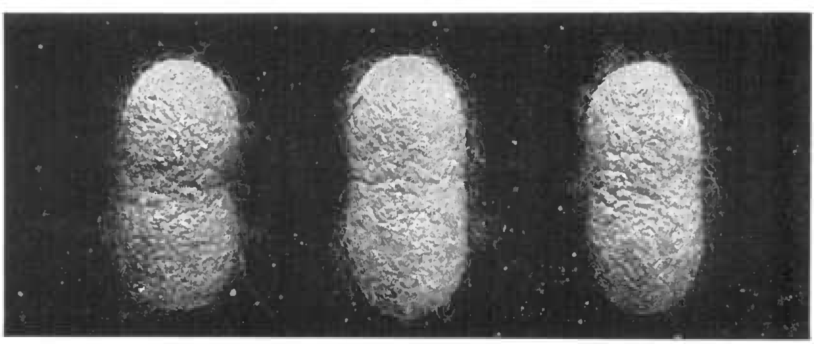


Fig. 3. ROUSILLON.

VARIOUS RACES OF COCOONS.

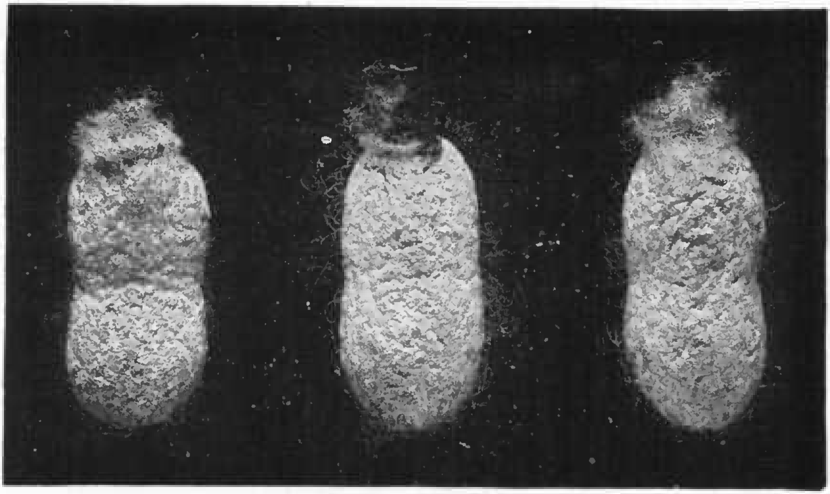


Fig. 1. VAR REPRODUCED IN THE ORIENTAL PYRENEES.

Fig. 2. CEVENNES.

Fig. 3. PERSIAN RACE, "SCHAZEVAR."

VARIOUS RACES OF COCOONS.

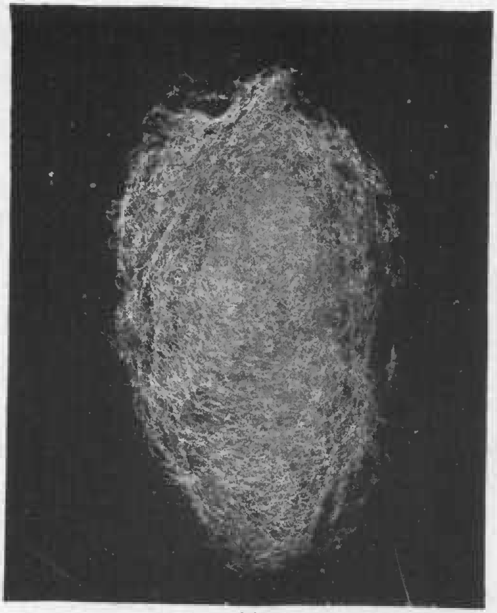


Fig. 1.

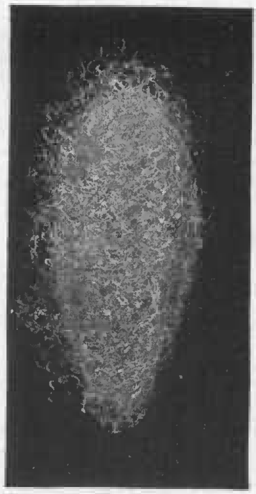


Fig. 2.

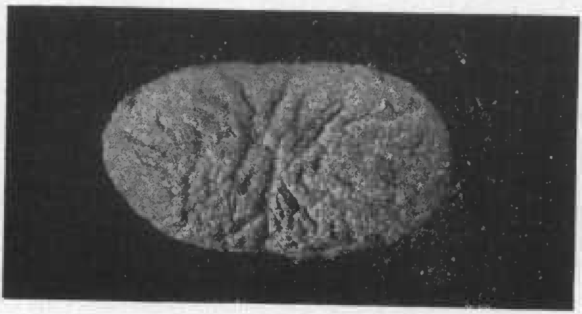


Fig. 3.

Fig. 4.

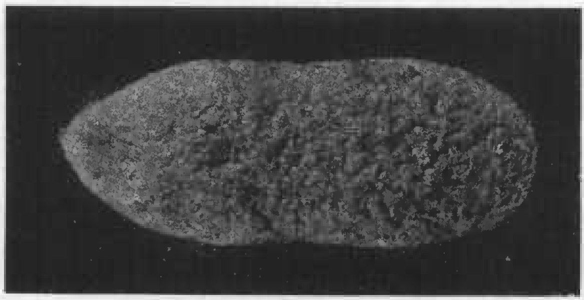


Fig. 5.

VARIOUS RACES OF COCOONS.

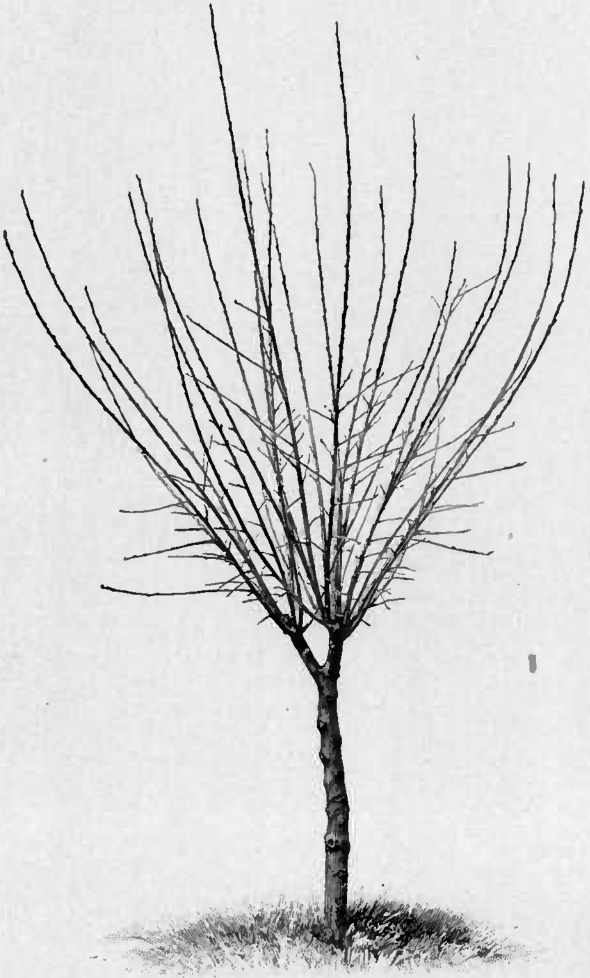


Fig. 1.

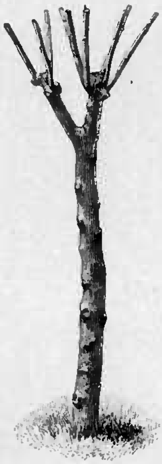
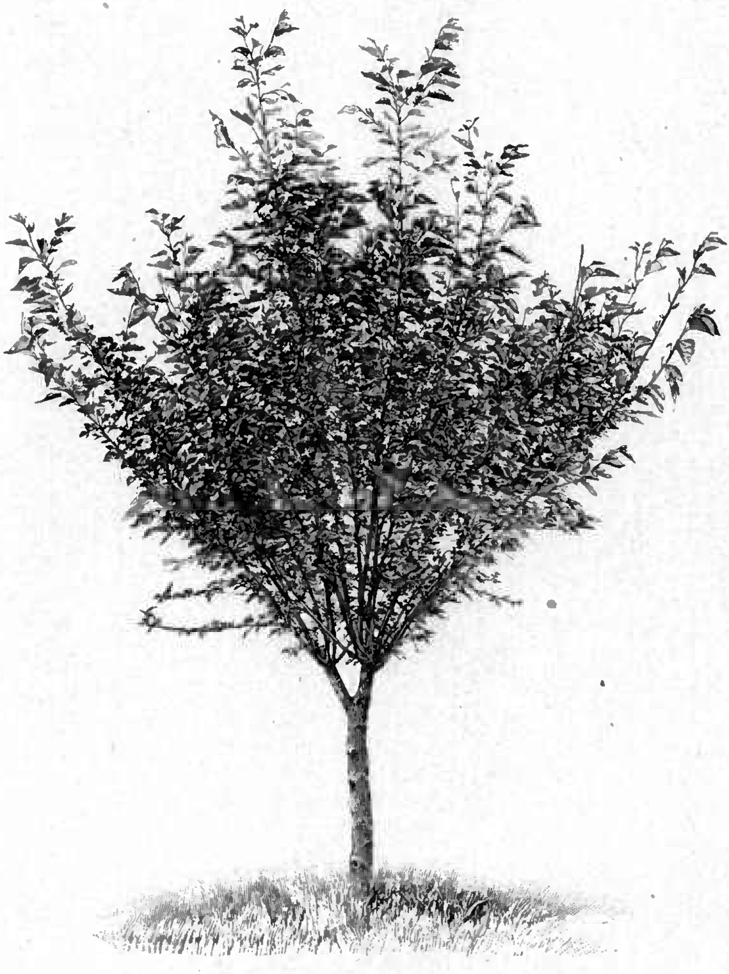


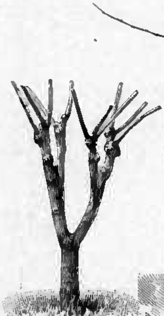
Fig. 2.

THE PRUNING OF MULBERRY TREES. HALF-STANDARD TREE.



HALF-STANDARD MULBERRY TREE.

Fig. 1.



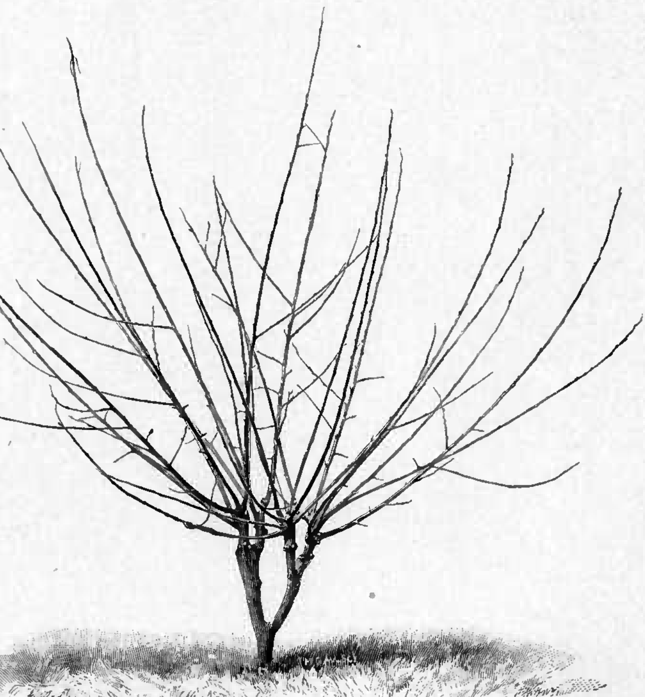


Fig. 2. Fig. 3.

PRUNING OF MULBERRY TREES. DWARF.

REPORT OF THE ORNITHOLOGIST AND MAMMALOGIST.

SIR: I have the honor to submit herewith my fifth annual report of the doings of the Division of Economic Ornithology and Mammalogy, covering the year 1890. It consists of two principal parts or sections in accordance with the two lines of work carried on by the Division—the one, a study of the *economic relations* of mammals and birds which are beneficial or harmful from a directly economic standpoint; the other, a study of the *geographic distribution of species.*

As stated in my last report, the office force of the Division is wholly insufficient for the rapidly increasing demands of the investigations in hand, and the mere routine work has already outgrown the means at command for its proper accomplishment. During the year 1890 about four thousand letters were written, copied, indexed, and mailed, and several thousand circulars and schedules were distributed. During the same period the number of letters received was more than five thousand, and more than half of these were accompanied by schedules, lists, reports, or other records of observations, all of which were examined, indorsed, jacketed, and either filed for future reference or at once utilized in studies already in progress. Other routine work has consisted in attending to the needs of field agents, in identifying specimens, comparing and correcting proof, preparing and revising card lists of correspondents, filing certain classes of reports received, typewriting franks for the distribution of documents to American and foreign correspondents, compiling a reference list of publications useful in the regular work of the Division, preparing colored diagrams or maps in connection with the work on geographic distribution, and miscellaneous work.

It is gratifying to record the fact that the restriction referred to in my last report as seriously affecting the scope of the work, has been removed by Congress, in obedience to your urgent recommendation, and that the Division is now in effect a biological survey, it having been authorized to undertake a comprehensive investigation of the geographic distribution of animals and plants.

I beg to call your attention to the inferior colored illustrations contained in the last annual report and in other publications of the Division. The originals from which these pictures were reproduced are of the highest quality, while the prints in the reports are the cheapest chromos—coarse, dauby, and differing widely in different copies. Such figures are discreditable to the Department and a disgrace to the National Government. Unless it is possible to obtain illustrations that are at least respectable it is better to do without them altogether.

Respectfully,

C. HART MERRIAM,
Chief of Division of Ornithology and Mammalogy.

HON. J. M. RUSK,
Secretary.

WORK OF THE YEAR.

SECTION OF GEOGRAPHIC DISTRIBUTION.

The work accomplished in the section of geographic distribution may be conveniently summarized under two heads, namely, (1) office work, and (2) field work.

(1) *Office work.*—The office work has consisted largely in collecting and tabulating records of the occurrence of certain species of mammals, birds, reptiles, and plants for the purpose of mapping their distribution; in working up the results of the field work carried on by the Division; in the care and arrangement of the material sent in by field agents and others; in the identification of specimens sent to the Department for that purpose, and in the preparation and publication of reports based on the investigations of the Division.

In mapping the distribution of species an obstacle is frequently encountered in the unsettled status of the species themselves, for it is impossible to map the distribution of animals which have not been named, and whose relationships are unknown. In the light of the large series of specimens collected by the Division in regions heretofore unvisited by naturalists, many groups require thorough revision before the species can be correctly named. The results of these critical studies appear in NORTH AMERICAN FAUNA, the publication containing the results of the scientific work of the Division. Two numbers of NORTH AMERICAN FAUNA (Nos. 3 and 4) have been prepared and issued during the year, the first comprising the results of a biological survey of the San Francisco Mountain region and desert of the Little Colorado, in Arizona; the second containing descriptions of a number of new species of North American mammals.

(2) *Field work.*—Field work has been carried on during the year in parts of Minnesota, Nebraska, Wyoming, Utah, Nevada, Idaho, Oregon, Washington, California, Texas, Mississippi, and Alabama, and several thousand specimens, including many species new to science, have been secured and now form a part of the national collections at Washington.

SECTION OF ECONOMIC RELATIONS.

The economic work of the Division, that devoted to the study of species directly injurious or beneficial to agriculture, has been confined mainly to investigations connected with the preparation of the four bulletins already announced, namely:

(1) *An illustrated bulletin on hawks and owls.*—This bulletin is now completed and will be published as soon as funds are available for the purpose. In its preparation the stomach contents of about 2,500 hawks and owls, representing 45 species, have been examined and the results tabulated; and to the mass of facts thus obtained the published observations of reliable naturalists throughout America have been added. The conclusions based on the study of this vast amount of material are irresistible. It is shown beyond question that the American hawks and owls, excepting the few species which habitually prey upon domesticated fowls or beneficial birds, are of great value to the farmer, destroying rats, mice, gophers, squirrels, and insects.

(2) *Bulletin on the gophers of the Mississippi Valley.*—Work on this bulletin has been continued during the year, and much valuable

information has been secured concerning the distribution and ravages of the several species.

(3) *Bulletin on crows.*—Work on this report has been continued, but it is deemed inexpedient to publish the result until additional material has been obtained. It is believed that some disputed points in the history of crows have been settled finally, but others need further study and experiment. The harm done to newly planted corn by crows is counterbalanced in some degree by their services as scavengers, and in the destruction of field mice and insects; moreover, comparatively inexpensive methods of protection have been found for this crop. But when the destruction of chickens, young birds, and eggs is added to the havoc wrought to grain and fruit during the summer and autumn, the account refuses to balance without additional evidence in favor of the crow. Such evidence *may* be found in the destruction of harmful insects; but in order to prove or disprove this claim, as well as to determine the extent of injury to the young and eggs of valuable birds, it is necessary to examine the stomachs of numerous crows killed under favorable circumstances during the spring and summer. One thousand stomachs (two thousand would be better) from farming lands in a dozen different States would make it possible to settle with comparative accuracy most of the disputed points, but such stomachs are not easily obtained. In response to an appeal in the Annual Report of 1888, a few offers of assistance were received, and eventually a few stomachs, but in almost every case the volunteer assistants found it much more difficult than anticipated to kill crows in warm weather, and less than one hundred crow stomachs in all have been received. A few of these were empty, and others were taken in cold weather, so that only two or three dozen contain evidence pertinent to the investigation. It is hoped that during the coming season farmers and others interested in the matter will coöperate with the Division in order to secure a sufficient number of stomachs for the completion of this work. Anyone willing to assist will be furnished directions on application to the Division.

The insect remains from the stomachs of fifty crows were submitted to Prof. C. V. Riley, Entomologist of the Department, for examination, and his report on them has been received.

(4) *Bulletin on crow blackbirds.*—It is intended to make this bulletin as thorough and comprehensive as that on the crow, and the work is being carried out in the same manner. Crow blackbirds are guilty of some of the same crimes as crows, but also have habits peculiar to themselves. As they nest in communities and may be found in flocks at all seasons in some parts of the United States there is less difficulty in collecting them, and the Division now has on hand about five hundred of their stomachs, many of which have been examined.

In connection with the three bird bulletins mentioned above, 1,017 stomachs have been examined since January 1, 1889, while about 250 more, mainly those of bobolinks, meadow-larks, bluebirds, and woodpeckers, have been examined in compliance with special requests for information as to the food of these particular species.

The bobolink stomachs were examined with a view to determining the summer food, and the results showed beyond question that during the breeding season these birds are not only harmless but decidedly beneficial. All the stomachs contained insects in abundance, and many of them larvæ injurious to grass lands.

The investigation of the food of the meadow-lark (*Sturnella magna*)

was undertaken in response to inquiries concerning its alleged fondness for clover seed; hence stomachs collected in autumn only were examined. These were thirty in number and were collected at various places in North Carolina, New York, Pennsylvania, and Tennessee during the months of October and November. At least 99 per cent of the contents of all these stomachs consisted of insects and only one contained no insects. The remaining 29 contained 25 caterpillars, 57 grasshoppers, and more than 80 beetles. About 100 seeds were found, of which 15 were clover, 13 wheat, oats, and corn, and the rest grass and weed seeds. Hence it is evident that the Meadowlark is one of the birds which the farmer should protect.

In connection with these food investigations the value of the reference collection of seeds has been demonstrated constantly. As yet it contains only about 240 genera of seeds, one third of which were added during the year. It still lacks many common species of the eastern United States on which some of our birds feed.

Since January 1 the collection of stomachs has been increased by 1,096, the total number now on hand being 11,812. During the same time 1,265 stomachs have been examined.

A biological clerk was added to the force of the Division in August and much better progress is now being made in the determination of the food contents of bird stomachs.

COLLECTIONS OF THE DIVISION.

The collection begun by the Division a little more than a year and a half ago has made gratifying progress, now numbering upwards of 4,000 specimens of mammals, 1,300 birds, and 500 reptiles and batrachians.

IDENTIFICATION OF SPECIMENS.

As stated in previous reports, the Division is prepared to identify and return specimens of mammals and birds received for that purpose. Such specimens may be sent by mail post free in packages to which return penalty envelopes are attached. The number of specimens received for identification from field agents and others during the past year aggregated more than 5,500. Notwithstanding the fact that much labor is involved in the determination of these specimens, and that their numbers are increasing year by year, every effort is made to give the work the attention its importance deserved.

SEED PLANTING BY BIRDS.

By WALTER B. BARROWS, *Assistant Ornithologist.*

For centuries the fact has been recognized that birds are instrumental in distributing the seeds of some plants, and that they are, to use a hackneyed expression, one of the agencies in forest rotation and in resurfacing with vegetation tracts swept bare by wind, water, fire, or the hand of man.

Examples of this kind of work by birds have been cited with some care and detail by a few good naturalists, while sweeping generalizations and extraordinary applications have been made by writers on popular natural history.

It is not for me, at least at the present time, to commend or criti-

cise either class, but with the hope of adding a few grains of solid truth to the common fund of knowledge, and particularly with the desire of awakening interest in facts which almost daily pass unnoticed by farmers, sportsmen, and field naturalists, I have brought together a few of the notes made in connection with the field work and routine examinations of bird stomachs in the U. S. Department of Agriculture.

The smaller land birds of a country, especially those supposed to be beneficial or harmful, are commonly divided into two great groups, insect-eaters and seed-eaters, and this division, though strongly artificial, still has some warrant in fact. When legislators wish to appear extremely exact without specifying each bird by name, they add another category, that of song-birds, and thus many of our State laws aim to protect song and insectivorous birds, while the seed-eaters, so-called, are denied any protection, or get what safety they can from alliance with "song-birds."

As a rule, however, the seed-eaters are not the seed-planters; on the contrary, the insectivorous birds more often sow seeds than the true seed-eaters, while the song-birds, particularly the thrushes and their allies, are still busier seed-planters. These statements, at first sight so contradictory, will become intelligible perhaps under the reminder that seeds, *as such*, are eaten for the kernel or embryo which they contain, and the grinding and digestion of this necessarily destroys the seed. Many fruits and so-called berries on the other hand, are eaten solely for the nourishing matter surrounding or attached to the seeds, and in most such cases the seed escapes destruction and is dropped either by ejection or rejection at a distance from the parent plant. In other words, seeds which *simply contain* nourishment are eaten and destroyed, while seeds which *are contained in nourishment* are eaten and survive.

Thus it happens that the armies of sparrows, finches, and similar birds in winter eat and destroy tons of grass seed and weed seed, while the same birds in summer and autumn may eat bushels of blueberries, huckleberries, elderberries, raspberries, strawberries, and similar fruits, and distribute their unharmed seeds over thousands of acres, which otherwise might never support a growth of these species.

But there is every reason to believe that the birds just mentioned do not eat, even at the height of the berry season, one quarter as many berries as some of the so-called insectivorous birds, such for example as the thrushes, catbird, mocking-bird, orioles, wax-wing, vireos, and woodpeckers. As a matter of fact, however, that which is definitely known on this subject is so little in comparison with what easily might be learned, that we can scarcely do more than call attention to our astounding ignorance of the food of some of our common birds.

The few berries already mentioned are such as ripen in summer or early autumn, and without exception disappear before cold weather sets in. Numerous other fruits, however, ripen during autumn and many of them clinging to the twigs throughout a considerable part of the winter afford a food supply for numerous late migrants and winter residents. Among such fruits may be mentioned the berries of the holly (*Ilex*), cat-briar (*Smilax*), bitter-sweet (*Celastrus*), sour-gum (*Nyssa*), flowering dogwood (*Cornus*), mountain ash and chokeberry (*Pyrus*), hackberry (*Celtis*), bayberry (*Myrica*), and the various sumachs and other species of the genus

Rhus. Anything like complete lists of the fruits eaten by birds, or of the birds which eat the different fruits would be tedious in the extreme, and moreover it is extremely improbable that any single individual or institution in this country possesses the data for making such lists.

The collection of stomachs in the Ornithological Division of the Department of Agriculture now numbers nearly 12,000, and is daily increasing, yet in this large collection very few species indeed are represented by a fair number of stomachs taken at all seasons of the year. Recently a question arose as to the food of the Upland Plover (*Bartramia*), and the collection being appealed to showed only a single stomach. A short time ago, after taking about one hundred seeds of five different kinds from less than a dozen stomachs of the Yellow-rumped Warbler (*Dendroica coronata*), I turned to compare these with the stomach contents of the Palm Warbler (*Dendroica palmarum hypochrysea*), and was disappointed to find but two stomachs of the latter species taken in autumn. All this is through no fault of the Division of Ornithology, but simply results from the size of the field. Several hundred species of birds are common in one part or another of our great country, and it is not to be expected that any collection can show a dozen stomachs of each species for each month of the year.

But although we may not at present list either the seeds that are eaten or the birds that eat them, we may get some useful hints and perhaps draw some conclusions from the facts which have been observed already. It has been stated that many insectivorous birds eat fruit. One of the most noteworthy examples of this kind is seen in the case of swallows, birds usually considered to be strictly insectivorous. I am free to confess that ten years ago I should have scouted the idea that swallows ate anything but insects, and had the farmers and fishermen along our Atlantic coast asserted then that swallows ate bayberries by the thousand in August, just before leaving for the South, in all probability I should not have given the matter a second thought, although the proof was directly at hand. Nevertheless it is now certain that several species of our swallows, notably the white-bellied, bank, and barn swallows, do feed very largely on the bayberry or waxberry (*Myrica cerifera*) wherever it is found; and my only regret is that I was so blind years ago as not to see that the swallows hovering by thousands among the bayberry bushes were greedily eating the berries instead of picking up flies as I then supposed. My eyes were first opened to this habit of the swallows by Dr. A. K. Fisher, and to the same person I am indebted for several similar hints, among others for notes relating to the fruit-eating habits of the vireos. Having seen a kingbird (*Tyrannus*) gorging himself with cultivated cherries about six years ago, my faith in purely insectivorous birds was considerably shaken, and the revelation in regard to swallows and bayberries completed its overthrow.

It may be remembered that the annual report of the Ornithologist of the Department of Agriculture for the year 1888 contained some statements in regard to crows eating seeds of poison ivy, statements for which the present writer was responsible. Among these was the remark that the excrement from a crow roost at Arlington Cemetery contained a large number of seeds of poison *Rhus*. Mr. Otto Widmann, of St. Louis, wrote me soon after stating that in his own experience with crows he had always found the seeds in the pellets or castings ejected from the mouth, never in the droppings.

This led to further investigations, and although in one or two instances seeds were found in the intestines of crows, it was found that the great majority of seeds, with much gravel and other indigestible matter, were ejected by the mouth after the nutritious matter had been digested.

Two living and healthy crows were procured, and were subjected to careful experiment for several months, and it was speedily shown that they were able to disgorge at will anything digestible or indigestible, or in any way distasteful. As for poison ivy berries one crow swallowed over eighty in a few moments, and within forty minutes ejected the seeds by the mouth, all cleaned, polished, and enveloped in a thick coating of sand. Whenever grain or seeds were fed to these birds they invariably swallowed large quantities of sand after it, scooping it up, a teaspoonful or more at a time, and washing it down with repeated swallows of water.

It seems hardly necessary to say that any bird who treats berries or stone fruits in this way, undoubtedly distributes the seeds under such conditions that many are sure to grow. In order to give some idea of the number of seeds thus distributed by crows alone, it was stated in the Annual Report for 1888 that a single pound of dried deposit taken from the Arlington roost contained by actual count 1,041 seeds of poison ivy (*Rhus toxicodendron*), 341 seeds of poison sumach (*Rhus venenata*), 3,271 seeds of other sumachs, 95 seeds of Virginia juniper, 10 seeds of flowering dogwood, and 6 seeds of sour-gum; a total of 4,764 seeds. The material, which covered about 4 square feet, was taken at random from above the layer of leaves and represented the average deposit on the roost at that time. As the roost covered upwards of 15 acres this would give a total in round numbers of 778 million seeds, or enough to plant more than 1,150 acres as closely as wheat is sown.

By actual experiment it was shown that at least 90 per cent of the poison seeds found at the roost were entirely uninjured, and under favorable conditions would grow. Of course the conditions were *not* favorable at the roost, and most if not all the seeds would perish, but it should be remembered that on an average the crows are at the roost only about one half the time during the winter, thus spending twelve hours of daylight scattered over the surrounding country, and twelve hours more at the roost. In view of what has been said about the rapidity of digestion in crows, it seems certain that as many seeds would be scattered away from as at the roost and many of these would be sure to grow.

It seemed perfectly natural to conclude that crows did much harm by thus sowing poisonous seeds; but while subsequent investigation does not lessen our estimate of the harm thus done, it appears that if we condemn the crow for this we must also condemn many other birds. How many we do not know, but we have found large numbers of seeds of poison sumach in the stomachs of the bluebird (*Sialia sialis*), Yellow-rumped Warbler (*Dendroica coronata*), Flicker (*Colaptes auratus*), Downy Woodpecker (*Dryobates pubescens*), Hairy Woodpecker (*D. villosus*), Pileated Woodpecker (*Ceophlœus pileatus*), and Bob White (*Colinus virginianus*), and there is little doubt that they will be found in the stomachs of many other birds when a systematic search is made. At the same time it is unsafe to predict it except in a very few cases.

Although the common crow undoubtedly is very fond of poison *Rhus* berries, the fish crow (*C. ossifragus*) appears to avoid them,

since the examination of twenty-six stomachs of this species failed to show even a trace of poison *Rhus*. This is the more remarkable because the stomachs did contain the seeds of many other fruits (including seeds of harmless sumachs), and it has been observed that fish crows seem to be much heartier fruit eaters than the common crows. Nevertheless the number of stomachs examined is far too small to base any argument upon, and it will not be strange if all the stomachs examined hereafter be found to contain large quantities of these seeds.

Similarly, it was at first believed that all the woodpeckers would be found to eat these poison berries in autumn and winter, but the recent examination of thirty stomachs of the yellow-bellied woodpecker (*Sphyrapicus*) failed to give any proof of it in this species, although the seeds of cherry, grape, sour-gum, and flowering dogwood were abundant.

One fact perhaps is worthy of note in connection with the fruit-eating habits of birds. It has been assumed, and in some cases undoubtedly has been proved, that the bright colors of fruits have been developed or acquired because of their usefulness in attracting the attention of animals which feed upon them. Both Darwin and Wallace speak particularly of red, yellow, and white fruits in relation to this use. In the case of the genus *Rhus*, we have common, harmless species which bear very conspicuous, large, compact bunches of red berries, which certainly are edible, and which yet contain comparatively little nourishment. The berries of the poison species of *Rhus*, on the contrary, are greenish or yellowish-white, mostly in small and inconspicuous clusters, yet they contain a relatively larger amount of nourishment than the harmless species. Berries of all the species are sought for and eaten by birds of many species, and the fruit clings to the stems very tenaciously, so that unless torn off by birds or other animals it would persist all winter. Now, it has been noticed that about Washington, even in open winters, when bird food of most kinds is reasonably abundant, the berries of poison sumach (*Rhus venenata*) disappear almost entirely before mid-winter, and those of the poison ivy (*Rhus toxicodendron*) become scarce soon afterward; while the more conspicuous berries of the harmless sumachs usually remain untouched until later in the season, and in many cases are never eaten at all. These facts would seem to indicate a nice power of discrimination on the part of birds, but I am not able to account satisfactorily for all the facts in this and similar cases.

I would also call attention to our lamentable ignorance as to the species of birds which have the habit already alluded to, of ejecting by the mouth seeds and other indigestible substances taken with food. What birds possess and exercise this power and what birds do not? Bluebirds swallow entire the large fruits of the sour-gum (*Nyssa*) and flowering dogwood (*Cornus florida*); do they eject the seeds, or is it possible that they pass entirely through the alimentary canal? Vireos feed on the large fruits of the sassafras and the even larger ones of some magnolias. In such cases what becomes of the seeds? These and scores of similar questions might be easily answered by any intelligent farmer or collector who would take the trouble to dissect a few specimens at the proper season, or to watch carefully caged specimens fed experimentally. Doubtless many already know just the points that others are wishing to know. Let me beg, then, that others may be given the benefit of your knowledge, and espe-

cially let me ask that so far as possible no collector will throw away the skinned carcass of a bird without at least a glance at the contents of the stomach and a brief note on the label of the skin. And if at times anyone, sportsman, collector, or farmer, finds it convenient to preserve and forward to the Department of Agriculture the stomachs of the specimens killed (no matter how common or well known they may be), the additional trouble taken will be acknowledged and fully appreciated by the Division of Ornithology, and may aid in the solution of economic questions of very great importance.

BIRDS WHICH FEED ON MULBERRIES.

By DR. C. HART MERRIAM.

Groves of mulberry trees during the period of fruiting are thronged by hundreds if not thousands of birds, comprising many species and representing diverse groups. Such insectivorous kinds as flycatchers, warblers, vireos, and even cuckoos, form a part of the heterogeneous assemblage, departing from their customary diet long enough to join the multitude of blackbirds, orioles, finches, sparrows, tanagers, waxwings, catbirds, bluebirds, and thrushes, which from daylight until dark gorge themselves upon the tender berries. It seems incredible that such small birds as warblers, vireos, and the least flycatcher can open their tiny mouths wide enough to swallow such large berries as they really do gulp down with little effort.

I know of no better tree than the mulberry to plant in public and private grounds for the purpose of attracting our resident birds; but unfortunately it does not thrive well north of the limits of the so-called Carolinian Life Zone. The black and the white mulberry (*Morus nigra* and *M. alba*) are the species here referred to.

The following list is incomplete, including such species only as have been actually observed, by Dr. A. K. Fisher and myself, in the act of feeding upon mulberries at Sing Sing, Westchester county, New York, and in the grounds of the Department of Agriculture, Washington, D. C. Several additional species seen in the trees with the others, but not noticed in the act of swallowing berries, are excluded.

Partial list of birds which feed on mulberries.

Yellow-billed Cuckoo (*Coccyzus americanus*).
Downy Woodpecker (*Dryobates pubescens*).
Kingbird (*Tyrannus tyrannus*).
Phœbe (*Sayornis phœbe*).
Wood Pewee (*Contopus virens*).
Least Flycatcher (*Empidonax minimus*).
Cowbird (*Molothrus ater*).
Orchard Oriole (*Icterus spurius*).
Baltimore Oriole (*Icterus galbula*).
Purple Grackle (*Quiscalus quiscula*).
Purple Finch (*Carpodacus purpureus*).
Goldfinch or Thistlebird (*Spinus tristis*).
Chipping Sparrow (*Spizella socialis*).
Song Sparrow (*Melospiza fasciata*).
English Sparrow (*Passer domesticus*).
Scarlet Tanager (*Piranga erythromelas*).
Cedar Waxwing (*Ampelis cedrorum*).
Red-eyed Vireo (*Vireo olivaceus*).
Warbling Vireo (*Vireo gilvus*).
Cape May Warbler (*Dendroica tigrina*).
Yellow Warbler (*Dendroica æstiva*).
Bay-breasted Warbler (*Dendroica castanea*).
Catbird (*Galeoscoptes carolinensis*).
Wood Thrush (*Turdus mustelinus*).
Robin (*Merula migratoria*).
Bluebird (*Sialia sialis*).

REPORT OF THE STATISTICIAN.

SIR: I have the honor to submit my twenty-second annual report as Statistician of the Department of Agriculture.

The office is better equipped for efficient service than in any former year. The clerical force is ample, and its *morale* high. There has always been a difficulty in obtaining efficient expert service for special investigation and for coördination of foreign statistics, from inability to pay what such service commands in unofficial station. In this respect there has been some amelioration, and further improvement is expected. But this branch of the service is ever handicapped by the existing clerical classification, which tends to reduce the civil list to a dead level of mediocrity.

Official exchanges are more extensive than ever before. Statistical documents are received directly from the principal governments of Europe, Asia, Australasia, South America, and from Canada and Mexico. Their diversity in language, denominations of money, and in weights and measures, as well as in methods and subjects of investigation, complicate and increase the labor of compilation and collaboration.

The crop-reporting service is more extended than at any former date, and the constant aim has been to increase its efficiency. It is duplicate in organization, one set of correspondents reporting directly to this office, the other to State agents, who consolidate their returns and report State averages for comparison with those produced by the tabulation of the regular returns. There are 2,338 counties, each represented by a chief correspondent, aided by at least three assistants, from which reports are regularly made to the Department. The corps of the State agents is also very large. Effort is made to obtain men of largest experience and best judgment for this service—men of ability and character, of promptness and reliability, of public spirit and *esprit de corps* as farmers. Some have been twenty years in the work. They have undoubtedly done more extensive and valuable service than any corps of voluntary correspondents in any line of organized effort in the history of the country—content with the compensation afforded by a consciousness of advancing the local and general interests of agriculture and promoting the public good. In both lists there are about thirteen thousand who regularly contribute to the preparation of the county estimates.

These correspondents are engaged in a grand work of primary statistical education. The masses of the people in this country are perhaps freer from ancient prejudices against the "numbering of the people," the census of crop production, and the publicity of information concerning current crop prospects than those of any other. Conscious of existence under free government and liberal institutions, they cower under no tyranny and fear no oppression. They seek only equitable compensation for their labor in production. To ob-

tain this a knowledge of the amount and quality of products, not only of this country but of other countries competing in the same markets, is absolutely necessary; and this can not be obtained in any other way so fully as by the Government in coöperation with other governments. Were it possible, as it is not, for American farmers to obtain this information without Government aid, and keep it a secret of their own, they would be at the mercy of speculators more than ever, as the great advantage and benefaction of national crop reports consists in their regulation of the wild movements of speculative trade, which does not hesitate to exaggerate conditions, misrepresent facts, invent misstatements, and circulate all this misinformation in newspapers of the largest circulation. This causes constant fluctuation in the market, not only facilitating speculating movements, but giving opportunity for largest actual buying of farmers when prices are most depressed. The tenor of best commercial opinion sustains the authoritative character of the national crop report.

The demand for agricultural statistics as a basis for legislation and for intelligent action in business, has never been more eager and general than in the past year. Representatives and citizens of foreign governments have been supplied with data in response to requests for information. Associations, industrial and commercial as well as agricultural, have sought statistics of production and distribution, and editors and authors are constantly requiring and receiving systematic collations of facts required in supplementing their own investigations.

The warmest expression of popular appreciation of the work of this office during the past year has been in commendation of the agricultural graphics extensively distributed to associations, commercial exchanges, schools, and libraries, especially the "Album of Agricultural Statistics." The edition is now practically exhausted, but a series under the name of "Album of Agricultural Graphics" is nearly ready for distribution, presenting the value per acre of each of the ten principal crops which are annually estimated. No small part of its utility comes from the fact that it gives, not the value for a single year, but the average of ten years, thus immensely increasing its value as a fair comparison of the averages of the different States. Another series, now ready for distribution, is a set of six large chromolithographic maps for the use of schools and agricultural institutes, showing the yield of wheat per acre, the distribution of oats and corn, the values of cows and other cattle, and the distribution of rural population.

Investigations are in progress to show the development of the agricultural resources of the Rocky Mountain States and Territories, and bulletins presenting such statistical surveys will be issued from time to time as rapidly as practicable.

Special investigation of the statistics and technology of the vegetable fibers, and those promising future development as sources of new industries, is in progress under an expert, and one report has been issued during the year. Others are in progress.

The office force at present consists of sixty persons, to whom acknowledgment is made of efficient service and willing coöperation in the work of the year.

J. R. DODGE,
Statistician.

Hon. J. M. RUSK,
Secretary.

CROPS OF THE YEAR.

A careful study of the meteorological records of the growing season during 1890 shows that the year was an abnormal one, both in distribution of temperature and rainfall over large sections of the most prominent agricultural States of the Union. With our wide expanse of territory there is almost every year in some portion an unfavorable season, resulting either from drought or an excess of moisture, or from both, at different periods during the season, but the present year is especially remarkable for its abnormal distribution of moisture. In the Atlantic States and in portions of the cotton belt there was a large excess over the normal rainfall; so much that considerable damage to cotton, potatoes, and some other crops resulted. This was more than balanced by the very heavy deficiency which prevailed in the Upper Mississippi and Missouri Valleys and on the Pacific coast, where the rainfall was so scant that over large areas the results of the season were disheartening in the extreme. In the Missouri Valley, including a large portion of the fertile soils of Nebraska, Kansas, and Northern Missouri, the deficiency in rainfall was accompanied during a portion of the year by exceedingly high temperature, making it a period of drought hardly equaled by any in the record of that agricultural region. During the growing season vast areas of yellow and shriveled corn and fields absolutely abandoned testified to the extremity of the disaster, and the final results of the harvest after husking was quite in keeping with the gloomy prospect.

A comparison of the Signal Service records shows that the effects of the drought of the present year were intensified by the fact that last season in the same districts there was a marked deficiency in the moisture supply, rendering the ground still more parched under the blazing sun and cloudless skies of the present year. In the following presentation from official records the aggregate rainfall during the growing season from April to September, for 1889 and 1890, as compared with the normal determined by the records of a series of years, is shown:

Districts.	Rainfall.			Departure of 1890 from the normal.	Departure of 1889 from the normal.
	For a series of years.	For 1890.	For 1889.		
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*
New England	21.49	22.44	26.47	+0.95	+ 3.23
Middle Atlantic	23.39	25.75	34.09	+2.36	+10.39
South Atlantic	31.53	32.22	31.68	+0.69	— 0.44
Eastern Gulf	30.37	29.21	28.63	—1.16	— 1.74
Western Gulf	23.83	26.85	22.80	+3.02	— 0.20
Ohio Valley and Tennessee	23.22	25.37	22.59	+2.15	— 0.62
Lower Lake region	19.82	22.55	16.48	+2.73	— 1.72
Upper Lake region	20.24	17.37	18.60	—2.87	— 1.51
Extreme Northwest	14.35	13.96	9.63	—0.39	— 4.73
Upper Mississippi Valley	23.05	18.88	19.91	—4.17	— 3.03
Missouri Valley	21.18	15.33	18.35	—5.85	— 3.15
North Pacific coast	14.77	10.07	14.22	—4.70	— 0.91

An analysis of this table shows that the season in New England was practically normal so far as water supply is concerned, though there was a considerable excess during September which seriously interfered with the harvest, especially of root crops, and extended to the Middle Atlantic States, where the remarkably wet year of 1889 was followed during 1890 by one in which there was a considerable excess of moisture, amounting to almost 2½ inches. During the

six months under consideration, in the South Atlantic and Eastern Gulf States the season varied slightly from the normal, and in the Western Gulf region there was an excess of precipitation over the normal of more than 12½ per cent. This excess was received mainly during May, June, and September, and the reports of our correspondents during the season indicated for these months some damage to crop prospects.

The Ohio Valley received almost 10 per cent more rainfall during the summer than its normal amount, and the fact that the excess came almost entirely during August and September increased the damage sustained. The Upper Mississippi Valley, including the Dakotas, Minnesota, and Iowa, suffered from a deficiency of precipitation amounting to more than 4 inches, or almost 20 per cent of the normal rainfall of that period. During 1889 the supply in the same territory was deficient by more than 3 inches. The Missouri Valley, already referred to, failed by almost 6 inches to receive its normal supply, and the deficiency amounted to almost 30 per cent. On the Pacific coast the winter of 1889–'90 was remarkably severe, and the amount of moisture received in the form of rain and snow unusually large. This resulted in disastrous floods and overflows during the early spring, but was followed by a diminished water supply during the summer months, amounting in the more northern districts to nearly 5 inches, or one third of the normal supply.

In order that a more extended comparison of the season may be made, a table showing the rainfall by districts and by months during the growing season of 1890, as compared with the average for a number of years, is appended. During any season a comparison in this detail by months is necessary, as while the total amount of rain received during six months might vary but little from the normal, the variance by months might be great enough to materially injure the harvest of the year. Gentle rainfall, evenly distributed throughout the season, with the proper intervals of sunshine, will bless agriculture with bountiful harvests, while the same amount coming in the form of sudden storms and washing floods will destroy the results of a season's work.

Average rainfall by districts.

Districts.	April.		May.		June.		July.		August.		September.	
	For several years.	1890.	For several years.	1890.	For several years.	1890.	For several years.	1890.	For several years.	1890.	For several years.	1890.
	In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
New England	3.58	3.23	3.54	4.67	3.18	3.25	3.96	3.05	4.22	3.54	3.01	4.70
Middle Atlantic States	3.28	2.88	3.25	4.31	3.96	2.62	4.46	4.33	4.76	5.90	3.68	5.71
South Atlantic States	3.95	2.34	3.87	5.22	5.24	2.33	6.20	8.46	6.72	5.21	5.55	8.66
Eastern Gulf States	5.35	2.75	4.44	6.34	5.53	4.23	5.24	6.97	5.44	4.40	4.37	4.52
Western Gulf States	4.33	6.08	4.87	4.68	3.73	4.86	3.25	1.85	3.20	3.78	4.45	5.60
Rio Grande Valley	1.01	3.39	3.42	2.84	2.64	2.20	1.81	2.63	3.86	1.02	6.22	0.95
Ohio Valley and Tennessee	4.24	4.10	3.92	4.24	4.33	4.17	4.18	2.18	3.63	5.07	2.92	5.61
Lower Lake region	2.33	2.99	3.13	5.32	3.72	3.58	3.50	1.77	3.13	3.48	4.01	5.41
Upper Lake region	2.36	2.57	3.39	4.01	4.04	3.52	3.34	2.50	3.35	3.10	3.76	1.67
Extreme Northwest	1.71	0.82	2.18	1.07	3.43	6.15	3.18	2.13	2.46	1.74	1.39	2.05
Upper Mississippi Valley	3.05	2.30	4.15	4.25	4.98	5.08	3.77	1.46	3.28	3.01	3.82	2.78
Missouri Valley	2.69	1.68	4.72	2.98	4.39	4.32	3.88	2.61	3.07	2.07	2.43	1.67
Northern slope	1.35	1.73	2.81	1.27	3.06	2.34	1.86	1.05	1.61	1.48	1.18	0.85
Middle slope	2.36	3.01	4.01	1.81	2.69	1.61	2.90	0.75	2.71	3.31	2.00	0.61
Southern slope	2.12	6.38	2.64	2.38	3.21	0.64	2.67	2.01	3.09	2.52	3.34	3.36
Southern plateau	0.41	0.78	0.41	0.02	0.49	0.11	2.12	2.24	2.55	3.25	1.28	1.44
Middle plateau	1.74	0.99	1.05	0.54	0.64	0.14	0.56	0.25	0.94	0.80	0.76	0.38
Northern plateau	1.57	0.41	0.99	1.53	1.67	1.32	......	......	0.42	0.26	......	......
North Pacific coast region	3.72	2.94	2.92	1.34	2.21	2.99	1.30	1.47	0.60	0.94	4.02	0.39
Middle Pacific coast region	2.65	1.40	0.71	1.85	0.36	0.07	0.01	0.01	0.01	......	0.33	0.89
South Pacific coast region	1.48	0.14	0.40	0.06	0.11	0.01	0.02	......	0.10	0.02	0.04	0.36

Almost as important in agricultural meteorology as proper rainfall well distributed is the range of temperature. The past season was almost as variable in heat distribution as in water supply. The season opened with April averaging from 1° to 4½° above the normal in the principal agricultural districts east of the Rocky Mountain region. West of that range the cold weather of the abnormal winter still continued. During May conditions were almost exactly reversed, and except east of the Alleghany chain and west of the Rocky range the month was from 1° to almost 5° below the average. This was accompanied in the main by an excess of rainfall, making it a cold wet month not favorable to the inception of farm work. In June, however, temperature ranged high, followed by a July which, as a rule, varied but little from the established records of a long series of years. During August and September the weather was generally cool in all districts, though the range from the normal was not so great as that noted earlier in the season. A record of the average temperature by districts is appended:

Average temperature by districts.

Districts.	April.		May.		June.		July.		August.		September.	
	For several years.	1890.	For several years.	1890.	For several years.	1890.	For several years.	1890.	For several years.	1890.	For several years.	1890.
	°	°	°	°	°	°	°	°	°	°	°	°
New England	43.8	44.5	53.7	53.9	63.4	62.2	68.7	67.9	67.5	67.4	61.9	62.1
Middle Atlantic States	51.5	53.0	63.2	62.8	71.5	73.4	76.3	74.5	74.2	73.3	68.8	68.1
South Atlantic States	62.0	63.0	70.6	71.5	77.7	80.8	80.6	78.7	79.3	78.0	74.7	75.3
Eastern Gulf States	66.8	67.1	73.3	72.1	79.5	80.0	81.7	80.8	80.5	79.1	76.5	75.6
Western Gulf States	64.9	65.9	73.2	72.2	80.2	78.8	83.0	82.6	82.0	80.6	76.5	73.7
Rio Grande Valley	76.0	75.4	80.0	79.7	84.0	82.3	85.4	85.0	84.4	84.8	81.0	81.0
Ohio Valley and Tennessee	56.4	57.4	66.4	64.6	73.9	77.6	77.6	77.4	75.6	73.4	69.7	67.5
Lower Lake region	44.2	45.8	57.5	54.1	66.2	69.4	71.1	71.1	69.1	67.1	63.8	60.8
Upper Lake region	40.2	41.7	52.1	47.5	61.4	65.2	67.2	68.1	65.3	63.2	59.2	57.2
Extreme Northwest	41.0	45.3	54.8	50.0	65.4	67.6	69.2	70.9	66.6	65.0	56.6	55.3
Upper Mississippi Valley	51.8	53.3	62.8	58.7	71.1	74.8	76.7	76.3	73.2	70.2	65.6	61.8
Missouri Valley	50.3	53.2	61.0	58.3	70.8	72.9	75.3	77.3	72.7	70.7	64.2	62.3
Northern slope	44.1	45.4	53.2	53.4	63.0	62.0	69.8	72.6	68.0	67.2	58.4	58.2
Middle slope	54.2	54.2	62.8	63.4	73.0	73.5	76.3	79.2	74.0	73.9	66.7	64.7
Southern slope	63.4	61.4	70.6	70.4	......	......	......	......	......	......	......	......
Southern plateau	57.9	59.5	66.7	68.7	74.9	73.6	80.7	81.2	78.0	75.8	71.2	72.3
Middle plateau	48.4	49.4	56.5	59.7	65.5	62.5	74.0	74.7	72.4	70.8	62.6	62.6
Northern plateau	49.4	50.2	58.0	59.2	64.6	61.6	......	......	......	......	......	......
North Pacific coast region	49.5	47.5	57.0	58.9	58.0	56.4	63.8	62.6	63.2	63.4	58.8	57.1
Middle Pacific coast region	58.3	58.0	63.0	64.3	67.3	66.5	71.6	71.3	71.0	71.3	68.7	68.4
South Pacific coast region	59.5	59.0	63.0	61.8	66.4	65.8	70.0	70.8	71.0	71.3	70.6	70.2

For convenience of examination, the departure from the normal, both in temperature and rainfall, for the districts comprising the principal agricultural sections of the country for each month during the growing season, is appended:

Districts.	April.		May.		June.		July.		August.		September.	
	Temperature.	Rainfall.	Temperature.	Rainfall.	Temperature.	Rainfall.	Temperature.	Rainfall.	Temperature.	Rainfall.	Temperature.	Rainfall.
	°	In.	°	In.	°	In.	°	In.	°	In.	°	In.
New England	+0.7	−0.35	+0.2	+1.13	−1.2	+0.07	−0.8	−0.91	−0.1	−0.68	+0.2	+1.69
Middle Atlantic	+1.5	−0.40	−0.4	+1.06	+1.9	−1.34	−1.8	−0.13	−0.9	+1.14	−0.7	+2.03
South Atlantic	+1.0	−1.61	+0.9	+1.35	+3.1	−2.91	−1.9	+2.26	−1.3	−1.51	+0.6	+3.11
Eastern Gulf	+0.3	−2.60	−1.2	+1.90	+0.5	−1.30	−0.9	+1.73	−1.4	−1.04	−0.9	+0.15
Western Gulf	+1.0	+1.75	−1.0	−0.19	−1.4	+1.13	−0.4	−1.40	−1.4	+0.58	−2.8	+1.15
Ohio Valley and Tennessee	+1.0	−0.14	−1.8	+0.32	+3.7	−0.16	−0.2	−2.00	−2.2	+1.44	−2.2	+2.69
Lower Lake region	+1.6	+0.66	−3.4	+2.19	+3.2	−0.14	0.0	−1.73	−2.0	+0.35	−3.0	+1.40
Upper Lake region	+1.5	+0.21	−4.6	+0.62	+3.8	−0.52	+0.9	−0.84	−2.1	−0.25	−2.0	−2.09
Extreme Northwest	+4.3	−0.89	−4.8	+1.11	+2.2	+2.72	+1.7	−1.05	−1.6	−0.72	−1.3	+0.66
Upper Mississippi Valley	+1.5	−0.75	−4.1	+0.10	+3.7	+0.10	−0.4	−2.31	−3.0	−0.27	−3.8	−1.04
Missouri Valley	+2.9	−1.01	−2.7	−1.74	+2.1	−0.07	+2.0	−1.27	−2.0	−1.00	−1.9	−0.76
North Pacific coast	−2.0	−0.78	+1.9	−1.58	−1.6	+0.78	−1.2	+0.17	+0.2	+0.34	−1.7	−3.63
Middle Pacific coast	−0.3	−1.25	+1.3	+1.14	−0.8	−0.29	−0.3	......	+0.3	−0.01	−0.3	+0.56

These records indicate an abnormal season and point to depreciated yields of crops most affected by such meteorological influences. A winter so mild that cotton in some situations was growing and flowering in midwinter, and seeds and grains sprouted and grew as volunteer crops, was not calculated to produce hardy growths that could withstand the inevitable fluctuations of March weather. In the Central and most of the Northern States the winter was unusually mild, grain was unprotected by snows and too succulent to endure the winds and frosts, which are sure to come before spring. The result was a worse injury of winter grain, over a wider area, than occurs in the average of bad seasons, and a frosting of citrus fruits on the Gulf coast and peninsula of Florida, which cut off a part of the season's crops and delayed the development of orange groves.

Winter wheat was injured seriously, and large areas in certain States were planted in other crops. Well-rooted plants, that in good soils or in tile-drained and drilled fields escaped the disruption so disastrous in "sprouting" soils, made good yields. A greater disparity in rate of yield has rarely been seen. From a heavy crop to a nearly absolute failure the range has been extreme.

Spring wheat started fairly well and improved slightly during June. In Minnesota a rank growth was reported and fears of blight from high temperature were entertained; chinch bugs began to threaten certain districts, and indications of rust appeared. In Dakota a deficiency of moisture was already apparent. During July there was a reduction in condition of eleven points. High temperature and hot winds wrought some damage to the ripening grain.

The changes in condition of winter and spring wheat from month to month as compared with those of 1889 are thus presented:

Year.	April.	May.	June.		July.		August.	When harvested.	
	W.	W.	W.	S.	W.	S.	S.	W.	S.
1889	94	96	93.1	94.4	92.0	83.3	81.2	89.4	83.8
1890	81	80	78.1	91.3	76.2	94.4	83.2	73.5	79.8

The corn crop started well with an average in July, the date of first report of condition, of 93.1, a figure higher than any in 1888 and 1889, and but little, if any, below an average July condition during the past decade. During July and August the drought, which was especially severe in the section growing the great bulk of commercial corn, set in, and in sixty days condition was reduced to 70.1 per cent. This rapid falling off in condition is only equaled by the decline which took place during the same period in 1887 from similar causes.

The weather during October was favorable for ripening and harvesting, frost holding off until the great bulk of the crop was hard and of merchantable quality, except as injured by the drought. It ripened well in northern New England, though in New York and Pennsylvania late maturation caused a considerable amount of soft corn. The excess of moisture during the latter part of the season along the Atlantic coast was rather unfavorable to ripening and delayed gathering and husking. The aggregate product is very much reduced, making only about 70 per cent of the great crop of 1889; the loss resulting from the smaller area harvested and the very heavy reduction in the rate of yield.

The returns of the oats crop were unfavorable from the beginning, condition at the June report, the first of the season, standing at only 89.8, or the lowest figure, with one exception, ever recorded in the crop-reporting history of the Department. This poor condition was due to unfavorable meteorological influences prevailing at time of sowing in many districts, and to drowning out of the crop in low and bottomlands by spring floods. During the month of June there was a decline in condition of 8 points, most severe along the Atlantic coast and in the Ohio Valley, and condition on the first of July was only 81.6. Over a large portion of the district of heavy production the plant was weak, enfeebled by alternations of temperature, and readily susceptible to damage from attacks of insects or blight. During July attacks of blight were reported in almost every section of the country except the Northwest, and condition fell away rapidly to 70.1 at the August report; the lowest figure ever reported for this crop in any month up to that date. At time of harvest, however, the injury sustained was still more apparent, and the result is a yield of only 19.8 bushels per acre, the lowest rate ever reported for this crop.

Of the minor cereals, rye and barley make yields considerably smaller than the average for a series of years, resulting from the same unfavorable conditions which shortened the product of the principal cereals. Buckwheat, however, coming later in the growing season, made a crop larger than usual, the yield being estimated at 14½ bushels upon an area somewhat in excess of that of 1889. With the exception of last year, this is the largest yield per acre reported during the past decade.

The potato crop suffered from unfavorable weather at time of planting and at time of harvest. This was especially true in New England and the Ohio Valley; condition throughout the season was low, and the returns of yield per acre were in close harmony with the season's record. The estimated yield per acre is only 57½ bushels, which, with two exceptions, is the lowest yield ever reported. The same conditions which injured the crop during the early growing season resulted in making the area smaller than was originally intended. The actual supply for consumption per head of population

of this important food crop is smaller than in any recent year. It should not be hastily assumed, however, that the apparent decline in the yield per acre of this crop during the past ten years is permanent, or that it results from any deterioration in fertility of soil or quality of seed. The last ten years have contained an unusually large number of seasons of unfavorable meteorological conditions—seasons of drought or of rainfall, or an injurious combination of both—which are hardly likely to reappear again with such frequency. With favorable weather, careful attention to selection of seed, and scientific rotation in cropping, a yield as large as any made in previous years may be confidently expected; in fact, during the past decade there were two favorable seasons when the outcome exceeded 90 bushels per acre.

The sugar crop has been a large one; the product of cane sugar in Louisiana being much in excess of that of last year, and undoubtedly the largest in thirty years. The year marks an important forward step in our experiments with other sugar-producing plants—the making of sugar from beets having been a commercial success in Nebraska, Kansas, and California. The results of this campaign give promise that the time when this country shall be less dependent for this staple article upon the plantations of foreign countries is at hand, and it may be that within a few years the $90,000,000 annually sent abroad will go to the pockets of our own farmers.

The hay crop of 1890 is above the average, both in breadth and in yield per acre. The extension of cultivated grasses in the South, and on the Great Western Plains, where formerly stock raising was carried on with no provision for winter feeding beyond that provided by nature in the dried buffalo and other wild grasses, which has been a marked feature of American agriculture during recent years, has continued. The search for grasses and forage plants which can withstand the high temperature and scanty moisture of the semi-arid districts of the Rocky Mountain regions continues. Alfalfa in many locations, especially where the scanty precipitation can be eked out with even a minimum distribution of water by irrigation, is regarded by many as a solution of the problem, and the increase in the product of this nutritious hay has been very rapid during recent years in Colorado, Wyoming, Utah, and other sections of the mountain region.

The estimated average yield per acre for the total area of all grasses cut for hay is 1.2 tons, a figure somewhat above the average for the past ten years. Except in the drought-stricken districts, the season was in the main favorable for maximum production, the excess of moisture characterizing the early spring months giving a strong, luxuriant growth which carried the crop through the less favorable period of its later growth.

The apple, peach, and small fruit crops were very deficient in almost every section of the country, except the Pacific coast, where there was a medium supply. The failure was the result of the mild, open winter which prevailed throughout the country east of the Rocky Mountains, the growth of new wood and of fruit buds continuing during the usual period of rest, making the variable weather of March unusually trying. California fruits and grapes have occupied a commanding position in the markets of the great cities, and the season was one of great prosperity to the horticultural interests of that State. The supply of oranges and other tropical fruits and delicacies from the Pacific coast and from Florida has been fairly

abundant, and each year demonstrates our ability to compete with foreign planters in new lines of production. Our possibilities for fruit production are becoming recognized, and the range is almost limitless.

The cotton crop of 1889 was the largest ever grown up to that date, but the indications of condition throughout the growing season with the annual enlargement of area, point to a somewhat larger product for 1890. We grow now three fourths of the cotton consumed in the manufactures of the civilized world, and as the demands for the fiber have quite kept pace with the increased product which our planters have marketed year after year, there has been no glut or overproduction, and prices have been maintained at a steady and remunerative level.

The increased interest in sheep husbandry, noted a year ago, has been continued, and this has been probably the most profitable branch of our stock industry during the year. The decline in wool production which began with the slaughter of flocks in 1884–'85, has been checked, the aggregate clip for 1890 (fall of 1889 and spring of 1890) being estimated at 276,000,000 pounds, an increase of 11,000,000 pounds over the previous season.

CEREAL CROPS OF THE YEAR IN DETAIL.

As noted in the general review, the season was distinctly unfavorable to full production of any of the staple cereals. Seeding and planting took place under discouraging circumstances; the period of early growth was attended by adverse meteorological conditions, the later season marked by alternations of flood and drought, and even the harvest interfered with by the lack of seasonable weather. All of these unfavorable conditions were, of course, not constantly present everywhere, but they were present throughout the whole crop year in one district or another of large production, and there is hardly a prominent grain State in which the yield per acre of corn, oats, or winter wheat is as large as the average of the past ten years.

It must not be presumed, however, that this partial crop failure will result in a stinted domestic food supply, or even prevent America from still being the granary from which the Old World may draw supplies with which to eke out her own deficiencies. With a crop of corn 30 per cent smaller than that of the previous year, making the smallest yield per acre with two exceptions noted in twenty years, we have a production per head of our population of 23 bushels, or 50 per cent more than the average production per capita of all cereals in Europe. Of wheat we have grown this year nearly twice the average per head of Europe, and our reserves, though somewhat depleted, with the small surplus which will remain over home requirements from this crop, will enable us to meet all probable foreign demands should ruling prices warrant a close clearing up of both visible and invisible stocks.

CORN.

The area of corn, which was slightly increased in planting, was reduced by failure and utter abandonment by more than 6,000,000 acres, the breadth harvested being estimated at 71,970,763 acres. In this breadth there is properly included all areas not absolutely abandoned, all fields, even though producing but a few bushels per acre,

and this fact, as well as that the estimated production is not in merchantable corn, but all corn—good, bad, soft, or nubbins—should be borne in mind in all comparisons with previous years, and in calculations of commercial supplies. The question of proportion of the crop merchantable is always investigated later, after husking and partial feeding of the crop give ample opportunity for mature judgment. The greater portion of the 6,000,000 acres planted but abandoned was of course in Kansas and Nebraska, the result of the severe drought which afflicted large areas in each State, but there was an unusually large area so lost in many other districts.

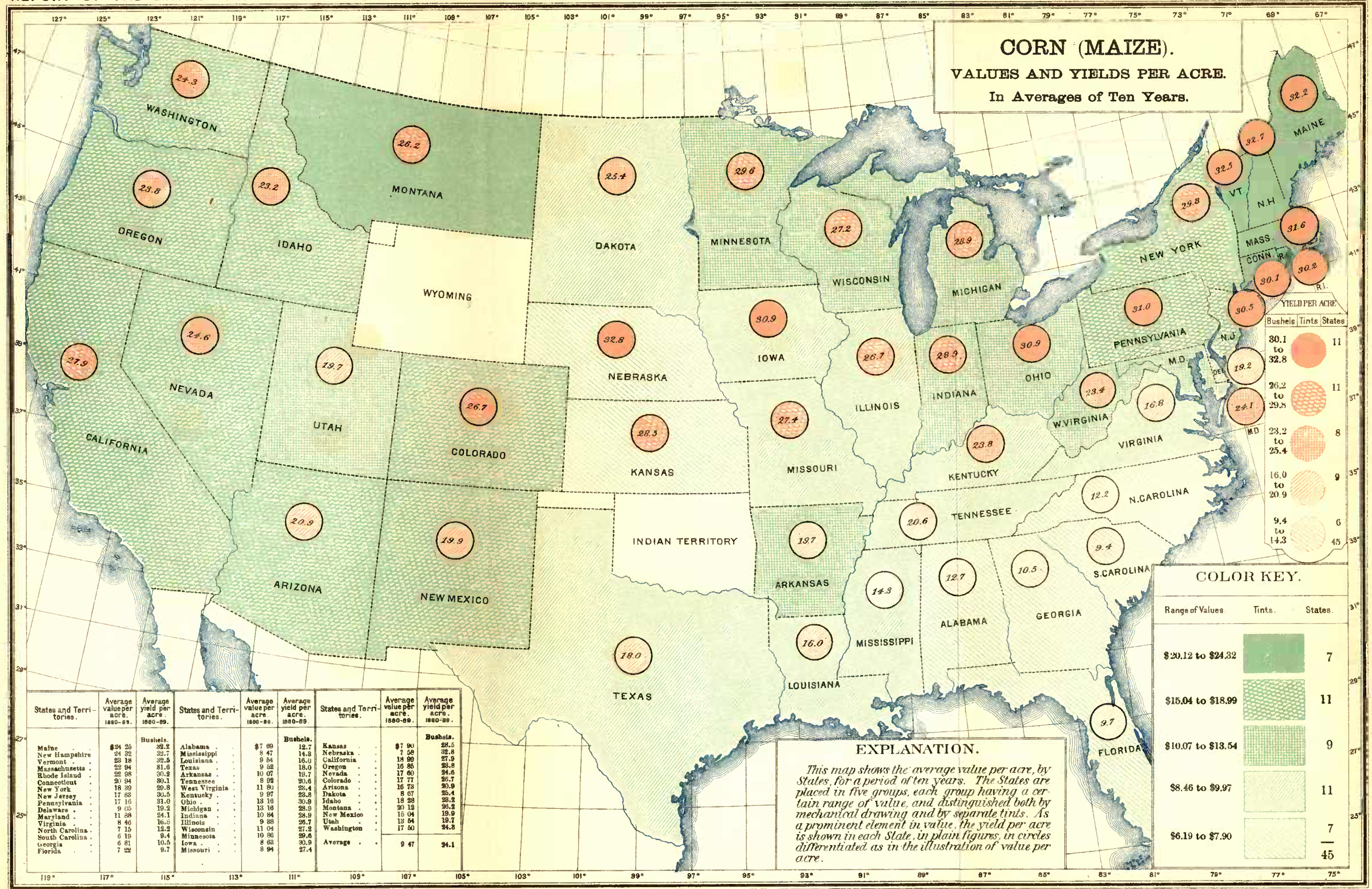
The estimated product is 1,489,970,000 bushels, or a yield of 20.7 bushels per acre. With the single exception of 1887, another year of severe drought, this is the smallest aggregate grown in any year since 1881. It is only 70 per cent of last year's great crop, but the disparity in commercial corn between the two seasons is even greater. The seven States of Ohio, Indiana, Illinois, Iowa, Missouri, Kansas, and Nebraska are the corn-surplus States, practically furnishing all that enters commercial channels. The crop in the other States is consumed where grown, and it exerts an influence on commercial corn only as it supplies home requirements or makes necessary a demand on the surplus States. Outside of these seven States the yield is practically only of local interest.

The returns of farm value of the crop show in a striking way the influence of short crops upon prices. While the crop aggregates only 70 per cent of that of last year, the aggregate money value of the crop to the producer is $156,000,000 greater.

The advance in value is in greater ratio than the decline in volume. It proves that the law of supply and demand still controls, and that small crops are a sure cure for low prices, but unfortunately the absolute failure of the crop in large districts prevents all growers from sharing in the average enhancement of the remaining product.

The estimated acreage, product, and value of the crop, by States, is thus presented:

States and Territories.	Acres.	Bushels.	Value.
Maine	27,855	1,008,000	$746,180
New Hampshire	34,487	1,259,000	906,319
Vermont	54,893	1,839,000	1,324,020
Massachusetts	54,134	1,868,000	1,307,336
Rhode Island	12,307	402,000	289,756
Connecticut	56,407	2,014,000	1,409,611
New York	642,896	17,101,000	11,115,672
New Jersey	357,342	11,185,000	6,934,579
Pennsylvania	1,383,377	38,043,060	22,825,721
Delaware	223,136	4,128,000	2,064,008
Maryland	725,907	16,333,000	8,166,454
Virginia	2,109,853	36,922,000	20,307,335
North Carolina	2,726,586	36,264,000	19,944,977
South Carolina	1,576,230	16,078,000	11,254,282
Georgia	2,981,486	31,306,000	21,600,866
Florida	491,428	4,570,000	3,427,710
Alabama	2,489,226	25,390,000	17,265,271
Mississippi	1,951,651	24,396,000	17,076,947
Louisiana	1,061,169	16,979,000	11,885,093
Texas	4,116,281	63,802,000	45,937,696
Arkansas	2,002,575	33,443,000	21,737,952
Tennessee	3,600,657	67,692,000	35,200,023
West Virginia	671,733	13,435,000	8,060,796
Kentucky	2,816,155	63,645,000	31,186,100
Ohio	2,827,277	65,876,000	33,596,533
Michigan	977,188	26,580,000	14,618,733
Indiana	3,604,252	89,025,000	41.841,761
Illinois	7,154,424	187,446,000	80,601,741
Wisconsin	1,102,022	33,061,000	14,877,297
Minnesota	768,449	21,236,000	8.940,136



States and Territories.	Average value per acre. 1880-89.	Average yield per acre. 1880-89.	States and Territories.	Average value per acre. 1880-89.	Average yield per acre. 1880-89.	States and Territories.	Average value per acre. 1880-89.	Average yield per acre. 1880-89.
		Bushels.			Bushels.			Bushels.
Maine	$24 25	32.2	Alabama	$7 69	12.7	Kansas	$7 90	28.5
New Hampshire	24 32	32.7	Mississippi	8 47	14.8	Nebraska	7 58	32.8
Vermont	23 18	32.5	Louisiana	9 54	16.0	California	18 99	27.9
Massachusetts	22 94	31.6	Texas	9 52	18.0	Oregon	16 85	23.8
Rhode Island	22 98	30.2	Arkansas	10 07	19.7	Nevada	17 60	24.6
Connecticut	20 94	30.1	Tennessee	8 92	20.6	Colorado	17 77	26.7
New York	18 39	29.8	West Virginia	11 80	23.4	Arizona	16 73	20.9
New Jersey	17 83	30.5	Kentucky	9 97	23.8	Dakota	8 67	25.4
Pennsylvania	17 16	31.0	Ohio	13 16	30.9	Idaho	18 28	23.2
Delaware	9 05	19.2	Michigan	13 16	28.9	Montana	20 12	26.2
Maryland	11 38	24.1	Indiana	10 84	28.9	New Mexico	16 04	19.9
Virginia	8 46	16.8	Illinois	9 88	26.7	Utah	13 54	19.7
North Carolina	7 15	12.2	Wisconsin	11 04	27.2	Washington	17 50	24.3
South Carolina	6 19	9.4	Minnesota	10 86	29.6			
Georgia	6 81	10.5	Iowa	8 63	30.9	Average	9 47	24.1
Florida	7 22	9.7	Missouri	8 94	27.4			

EXPLANATION.

This map shows the average value per acre, by States, for a period of ten years. The States are placed in five groups, each group having a certain range of value, and distinguished both by mechanical drawing and by separate tints. As a prominent element in value, the yield per acre is shown in each State, in plain figures, in circles differentiated as in the illustration of value per acre.

Geo. S. Harris & Sons Lith. Phila.

States and Territories.	Acres.	Bushels.	Value.
Iowa	8,771,209	232,439,000	95,300,164
Missouri	6,796,318	175,345,000	77,151,802
Kansas	3,542,891	55,269,000	28,187,241
Nebraska	3,072,800	55,310,000	26,548,992
California	159,871	4,396,000	2,857,694
Oregon	8,011	173,000	114,205
Colorado	42,133	767,000	483,097
The Dakotas	884,593	12,030,000	6,015,233
New Mexico	56,289	1,126,000	821,819
Utah	35,175	739,000	502,299
Total	71,970,763	1,489,970,000	754,433,451

For purpose of comparison a presentation, in condensed form, of the results for a long series of years is given. An examination of the table shows that with one exception the crop of 1890 is the smallest of the decade and with the same exception the most valuable per unit of quantity. The course of price follows closely the course of product, the highest price going with the smallest crop, in 1881, and the lowest price with the largest crop, in 1889. The decline in average yield between the period 1870–'79 and 1880–'89 can not be attributed to any decline in fertility or be considered as permanent. The first period included an unusually large number of fat years, years of plenty, in which nature smiled upon the efforts of the husbandman, while the latter number many that were lean, when droughts and floods robbed the worker of the fruits of his labor.

The statement is as follows:

Years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value per acre.
	Bushels.	*Acres.*		*Cents.*	*Bushels.*	
1880	1,717,434,543	62,317,842	$679,714,499	39.6	27.6	$10.91
1881	1,194,916,000	64,262,025	759,482,170	63.6	18.6	11.82
1882	1,617,025,100	65,659,545	783,867,175	48.5	24.6	11.94
1883	1,551,066,895	68,301,889	658,051,485	42.4	22.7	9.63
1884	1,795,528,000	69,683,780	640,735,560	35.7	25.8	9.19
1885	1,936,176,000	73,130,150	635,674,630	32.8	26.5	8.69
1886	1,665,441,000	75,694,208	610,311,000	36.6	22.0	8.06
1887	1,456,161,000	72,392,720	646,106,770	44.4	20.1	8.93
1888	1,987,790,000	75,672,763	677,561,580	34.1	26.3	8.95
1889	2,112,892,000	78,319,651	597,918,829	28.3	27.0	7.63
1890	1,489,970,000	71,970,763	754,433,451	50.6	20.7	10.48
Total	18,524,400,538	777,405,336	7,443,857,149			
Average, 11 years, 1880 to 1890	1,684,036,413	70,673,212	676,714,286	40.2	23.8	9.58
Average, 10 years, 1880 to 1889	1,703,443,054	70,543,457	668,942,370	39.3	24.1	9.48
Average, 10 years, 1870 to 1879	1,184,486,954	43,741,331	504,571,048	42.6	27.1	11.54

The great bulk of our corn crop is used at home, in fact is consumed upon the farms where grown, and but a very small proportion is ever shipped abroad. The shipments, however, small as they are, are extremely variable, depending entirely upon the domestic price. When the volume was greatest it amounted to but 6.5 per cent of the crop, and from that it ranges down to 1 per cent. The production and exportation, with the annual average of each for twenty years, is presented in the following statement, showing that during that period the foreign demand has amounted to only 3.9 per cent of our production.

Production and export of corn.

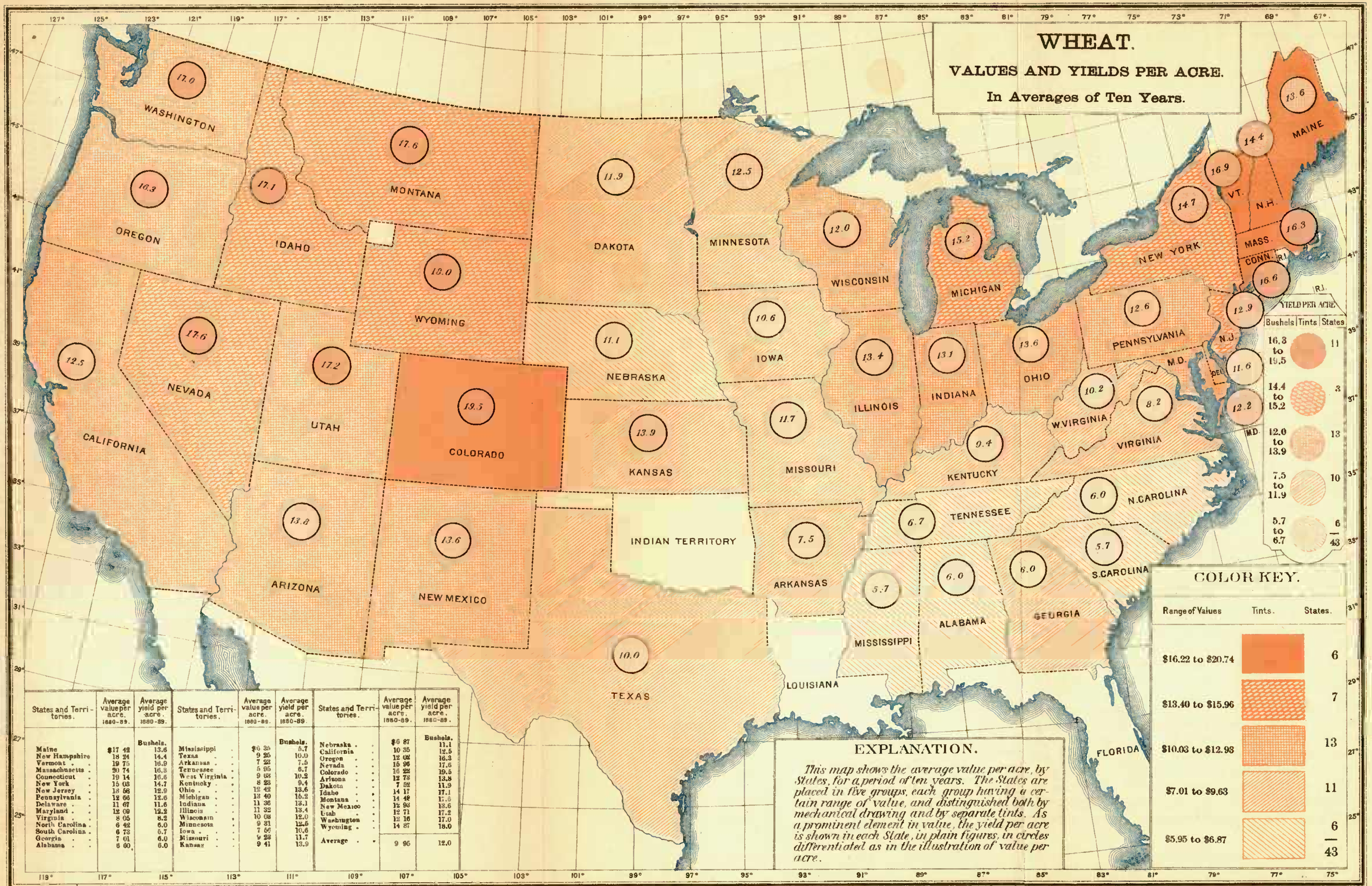
Years.	Production.	Exports.	Exportation.	Years.	Production.	Exports.	Exportation.
	Bushels.	*Bushels.*	*P. ct.*		*Bushels.*	*Bushels.*	*P. ct.*
1870	1,094,255,000	10,673,553	1.0	1881	1,194,916,000	44,340,683	3.7
1871	991,898,000	35,727,010	3.6	1882	1,617,025,100	41,655,653	2.6
1872	1,092,719,000	40,154,374	3.7	1883	1,551,066,895	46,258,606	3.0
1873	932,274,000	35,985,834	3.9	1884	1,795,528,000	52,876,456	2.9
1874	850,148,500	30,025,036	3.5	1885	1,936,176,000	64,829,617	3.3
1875	1,321,069,000	50,910,532	3.9	1886	1,665,441,000	41,368,584	2.5
1876	1,283,827,500	72,652,611	5.7	1887	1,456,161,000	25,360,869	1.7
1877	1,342,558,000	87,192,110	6.5	1888	1,987,790,000	70,841,673	3.6
1878	1,388,218,750	87,884,892	6.3	1889	2,112,892,000	103,418,709	4.9
1879	1,754,591,676	99,572,329	5.7				
1880	1,717,434,543	93,648,147	5.5	Annual average	1,454,299,498	56,768,864	3.9

WHEAT.

The estimate of the wheat crop of 1890 was closely foreshadowed by the various returns of condition throughout the season. The October estimate of yield per acre is confirmed by later investigations, by returns of thrashing, and by the record of individual cultivators received and tabulated during December. The aggregate area harvested is estimated at 36,087,154 acres, against 38,123,859 acres in 1889 and 35,430,333 acres in 1879. This shows but little increase in the breadth harvested during the last ten years, though within that period the acreage ran up to nearly 40,000,000 acres in 1884 and fell away to 34,000,000 in 1885.

The total product is estimated at 399,262,000 measured bushels. The commercial demand that the crop be given in bushels by weight can not be acceded to. While in elevators, on railroads, and in commercial transactions the bushel means 60 pounds without regard to volume, yet farmers are accustomed to use and to think in the measured bushel. To require them to still further complicate their estimates of yield per acre by a mental calculation of quality to ascertain average weight would be unreasonable and the results misleading. The question of quality and weight is an after consideration, and is reported upon by this office in March of each year, when records of inspections are available, when millers and elevator men by actual tests of the scales can give authoritative answers. It is well known that no crop ever averages up to the standard of 60 pounds per bushel, the average for a series of years being probably between 57 and 58 pounds. Past records have shown that the annual variance in weight of the crop is not much more than a pound above or below this average, the extreme range in seven years being from 56.5 in 1888 to 58.5 in 1887.

The season was especially unfavorable in the winter-wheat States, those east of the Rocky Mountains suffering from damage wrought by March freezing when fields were bare of snow protection, and the Pacific coast from floods and overflows in the early spring. In no State in which the winter grain makes the bulk of the product is the rate of yield as high as the State average of the last ten years. The year was more favorable in the spring-wheat districts, the yield in the principal States, except the Dakotas, being quite as large as



States and Territories.	Average value per acre. 1880-89.	Average yield per acre. 1880-89.	States and Territories.	Average value per acre. 1880-89.	Average yield per acre. 1880-89.	States and Territories.	Average value per acre. 1880-89.	Average yield per acre. 1880-89.
		Bushels.			Bushels.			Bushels.
Maine	$17 42	13.6	Mississippi	$6 35	5.7	Nebraska	$6 87	11.1
New Hampshire	18 24	14.4	Texas	9 25	10.0	California	10 35	12.5
Vermont	19 75	16.9	Arkansas	7 23	7.5	Oregon	12 02	16.3
Massachusetts	20 74	16.3	Tennessee	5 95	6.7	Nevada	15 96	17.6
Connecticut	19 14	16.6	West Virginia	9 68	10.2	Colorado	16 22	19.5
New York	15 03	14.7	Kentucky	8 23	9.4	Arizona	12 73	13.8
New Jersey	13 56	12.9	Ohio	12 42	13.6	Dakota	7 52	11.9
Pennsylvania	12 66	12.6	Michigan	13 40	15.2	Idaho	14 17	17.1
Delaware	11 67	11.6	Indiana	11 36	13.1	Montana	14 48	17.6
Maryland	12 09	12.2	Illinois	11 32	13.4	New Mexico	12 93	13.6
Virginia	8 05	8.2	Wisconsin	10 03	12.0	Utah	12 71	17.2
North Carolina	6 42	6.0	Minnesota	9 31	12.5	Washington	12 16	17.0
South Carolina	6 73	5.7	Iowa	7 56	10.6	Wyoming	14 87	18.0
Georgia	7 01	6.0	Missouri	9 23	11.7			
Alabama	6 00	6.0	Kansas	9 41	13.9	Average	9 95	12.0

the average. The division into spring and winter wheat is thus made:

	Acres.	Bushels.	Per acre.
Spring	12,567,050	143,888,000	11.4
Winter	23,520,104	255,374,000	10.9

The value of our wheat crop, unlike that of corn, which is regulated by the domestic demand alone, is dependent upon other factors than the volume of our own crop. Its price is affected by the supply of the world, drawn from all sources of production, and as a consequence we have had some large crops with high prices and small crops with lower values. The crop of the United States, however, is a prominent element in determining the world's surplus, and to that extent determines values. The farm value of the present crop has advanced to nearly 84 cents per bushel, and the aggregate value is $334,773,678, only $8,000,000 short of the value of the crop of 1889, although the crop is smaller by more than 90,000,000 bushels.

The estimates in detail, by States, are as follows:

States and Territories.	Acres.	Bushels.	Value.
Maine	40,213	543,000	$624,307
New Hampshire	9,155	140,000	161,083
Vermont	19,478	335,000	371,874
Connecticut	1,876	30,000	33,018
New York	640,540	9,288,000	9,287,830
New Jersey	138,833	1,680,000	1,679,879
Pennsylvania	1,337,437	16,049,000	15,888,752
Delaware	94,790	919,000	882,684
Maryland	535,143	6,208,000	5,711,046
Virginia	801,956	5,614,000	5,389,144
North Carolina	717,228	3,156,000	3,155,803
South Carolina	178,609	750,000	787,666
Georgia	344,159	1,411,000	1,552,157
Alabama	293,049	1,319,000	1,437,406
Mississippi	60,750	286,000	314,078
Texas	510,711	3,575,000	3,396,228
Arkansas	221,848	1,575,000	1,543,619
Tennessee	1,175,052	7,873,000	7,636,663
West Virginia	302,086	2,326,000	2,209,759
Kentucky	943,518	9,152,000	8,419,955
Ohio	2,398,741	29,984,000	27,285,679
Michigan	1,701,561	20,271,000	18,243,967
Indiana	2,493,605	27,928,000	24,576,971
Illinois	1,853,173	18,161,000	15,800,153
Wisconsin	1,073,475	13,096,000	10,870,008
Minnesota	3,143,917	38,356,000	31,068,187
Iowa	1,685,080	19,041,000	15,233,123
Missouri	1,603,459	17,638,000	14,639,581
Kansas	2,058,000	28,195,000	21,709,842
Nebraska	1,418,059	15,315,000	11,639,428
California	2,426,730	29,121,000	22,131,778
Oregon	887,250	12,865,000	9,648,844
Nevada	18,489	250,000	214,658
Colorado	96,030	1,777,000	1,439,010
Arizona	25,930	311,000	280,044
The Dakotas	4,209,482	40,411,000	28,287,719
Idaho	83,056	1,370,000	1,068,931
Montana	87,550	1,488,000	1,190,680
New Mexico	90,610	1,105,000	1,050,170
Utah	130,251	2,279,000	1,777,927
Washington	436,275	8,071,000	6,134,027
Total	36,087,154	399,262,000	334,773,678

An examination of the results of each harvest since 1880 shows that in but two years has the average yield been lower than that of the present crop, in 1881 and in 1885, the only years in which the de-

ficiency in an aggregate volume was greater. At the same time the average value of the crop has been greater in five years of the eleven, showing that price is influenced in a large measure by the crops of other lands. The average yield per acre has been very uniform during each of the ten-year periods since 1870, the difference being less than one-third of a bushel.

Years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value per acre.
	Bushels.	*Acres.*		*Cents.*	*Bushels.*	
1880	498,549,868	37,986,717	$474,201,850	95.1	13.1	$12.48
1881	383,280,000	37,709,020	456,880,427	119.2	10.2	12.12
1882	504,185,470	37,067,194	444,602,125	88.2	13.6	11.99
1883	421,086,160	36,455,593	383,649,272	91.1	11.6	10.52
1884	512,765,000	39,475,885	330,862,260	64.5	13.0	8.38
1885	357,112,000	34,189,246	275,320,390	77.1	10.4	8.05
1886	457,218,000	36,806,184	314,226,020	68.7	12.4	8.54
1887	456,329,000	37,641,783	310,612,960	68.1	12.1	8.25
1888	415,868,000	37,336,138	385,248,030	92.6	11.1	10.32
1889	490,560,000	38,123,859	342,491,707	69.8	12.9	8.98
1890	399,262,000	36,087,154	334,773,678	83.8	11.1	9.28
Total	4,896,215,588	408,878,773	4,052,868,719	....	....	....
Average, 11 years, 1880 to 1890	445,110,508	37,170,798	368,442,611	82.8	12.0	9.91
Average, 10 years, 1880 to 1889	449,695,359	37,279,162	371,809,504	82.7	12.1	9.97
Average, 10 years, 1870 to 1879	312,152,728	25,187,414	327,407,258	104.9	12.4	13.00

OATS.

There is a decrease from the acreage of 1889 of slightly more than a million acres in the area of oats harvested, but the great falling off in the volume of the crop is the result of the deficient yield per acre. The year was especially unfavorable for this crop from the beginning, and the final yield is the logical sequence of the returns of condition throughout the growing season. The steady enlargement in the volume of this crop has been one of the features of our agriculture during the past decade, and, like corn, the demand has been for domestic consumption. Its use for human food is steadily increasing, though the aggregate thus used is small. Like corn it is used as feed for animals, and there is an intimate relation between the two grains growing out of their interchangeable use. The value of the crop depends partially upon the size of the corn crop, and the present crop, short itself, and coming with a small corn yield, commands a high price. The farm price is the highest in ten years, except in 1881, another year of short corn yield.

The yield per acre averages but 19.8 bushels, the lowest ever returned by this office, while the average for a series of years would not be far from 27 bushels.

As in the case of corn, the short crop of the present year is worth more in the aggregate to producers than the crop of 1889, which was the largest ever grown. With a decline in volume of more than 225,000,000 bushels there is an absolute increase in value of $50,000,000. There is a lesson of wisdom in these figures, a remedy for low prices.

The estimates in detail are as follows:

States and Territories.	Acres.	Bushels.	Value.
Maine	100,607	2,847,000	$1,622,891
New Hampshire	31,359	862,000	482,929
Vermont	106,591	2,793,000	1,396,342
Massachusetts	23,275	598,000	328,992
Rhode Island	6,545	153,000	82,703
Connecticut	39,019	780,000	413,601
New York	1,343,418	23,913,000	11,956,420
New Jersey	141,537	2,449,000	1,224,295
Pennsylvania	1,277,424	21,972,000	10,546,413
Delaware	22,931	298,000	134,146
Maryland	113,075	1,357,000	597,036
Virginia	672,178	6,587,000	2,964,305
North Carolina	673,672	6,198,000	3,160,869
South Carolina	393,226	4,168,000	2,500,918
Georgia	562,387	5,455,000	3,273,092
Florida	53,540	573,000	349,456
Alabama	405,344	4,864,000	3,015,759
Mississippi	361,992	4,778,000	2,866,976
Louisiana	42,952	567,000	345,849
Texas	639,274	11,059,000	6,082,692
Arkansas	293,831	3,967,000	2,102,361
Tennessee	682,759	6,486,000	2,918,795
West Virginia	142,107	1,506,000	677,850
Kentucky	465,152	3,954,000	1,779,206
Ohio	1,111,332	20,004,000	8,401,670
Michigan	941,088	25,033,000	11,014,494
Indiana	1,017,122	17,800,000	7,297,850
Illinois	3,372,451	70,821,000	29,036,803
Wisconsin	1,496,888	38,919,000	15,567,635
Minnesota	1,500,084	38,402,000	14,208,796
Iowa	2,767,330	71,397,000	27,130,903
Missouri	1,412,571	24,579,000	9,585,707
Kansas	1,302,884	31,269,000	11,882,302
Nebraska	1,053,059	22,430,000	8,747,761
California	70,655	1,943,000	1,088,087
Oregon	221,940	6,658,000	3,329,100
Colorado	100,725	2,498,000	1,248,990
The Dakotas	1,183,157	24,846,000	7,950,815
Idaho	36,440	1,093,000	634,056
Montana	90,235	2,797,000	1,650,398
New Mexico	16,330	392,000	223,394
Utah	38,491	1,059,000	582,177
Washington	104,392	3,497,000	1,643,652
Total	26,431,369	523,621,000	222,048,486

The bushel value of the present crop has been exceeded but once during the past decade, in 1881. In that year the yield was only slightly below the average for ten years, and the crop was one of generous proportions. The price was high because of the short corn crop, admirably illustrating the relations between the two grains. The rapid enlargement of the area devoted to oats is shown by the fact that the average breadth between 1880 and 1890 is more than double that between 1870 and 1880. A slight diminution in the rate of yield, however, has prevented the average product from doubling during the same period.

Years.	Total production.	Total area of crop.	Total value of crop.	Average value per bushel.	Average yield per acre.	Average value per acre.
	Bushels.	*Acres.*		*Cents.*	*Bushels.*	
1880	417,885,380	16,187,977	$150,243,565	36.0	25.8	$9.28
1881	416,481,000	16,831,600	193,198,970	46.4	24.7	11.48
1882	488,250,610	18,494,691	182,978,022	37.5	26.4	9.89
1883	571,302,400	20,324,962	187,040,264	32.7	28.1	9.20
1884	583,628,000	21,300,917	161,528,470	27.7	27.4	7.58
1885	629,409,000	22,783,630	179,631,860	28.5	27.6	7.88
1886	624,134,000	23,658,474	186,137,930	29.8	26.4	7.87
1887	659,618,000	25,920,906	200,699,790	30.4	25.4	7.74
1888	701,735,000	26,998,282	195,424,240	27.8	26.0	7.24
1889	751,515,000	27,462,316	171,781,008	22.9	27.4	6.26
1890	523,621,000	26,431,369	222,048,486	42.4	19.8	8.40
Total	6,367,579,390	246,395,124	2,030,712,605	....	....	....
Average, 11 years, 1880 to 1890	578,870,854	22,399,557	184,610,237	31.9	25.8	8.24
Average, 10 years, 1880 to 1889	584,395,839	21,996,376	180,866,412	30.9	26.6	8.22
Average, 10 years, 1870 to 1879	314,441,178	11,076,822	111,075,223	35.3	28.4	10.03

FARM ANIMALS.

The annual estimates of increase or decrease in farm animals are made in January, and are published in the January-February report, which has not been prepared, the annual going to press much earlier than usual. These estimates will be found in that report, which will be issued in February. The winter of 1890-'91 was unusually severe in the range regions, especially in Northern latitudes and on the Pacific coast, though the season east of the Missouri was one of extraordinary mildness. The losses in Washington and Oregon were very heavy, according to information apparently reliable, in some districts taking half to three fourths of all the cattle. The April report made the loss about two million cattle, and it is probable that the full depreciation was not revealed, especially as to the Pacific slope. A considerable reduction in numbers of cattle is probable. The facts, as nearly as they can be approximated, will be indicated in detail in the first report of the Statistician in 1891, the issue for January-February.

DISTRIBUTION OF DOMESTIC ANIMALS.

The increase in the commercial movement of farm animals during the past twenty years is one of the most striking facts in the commerce of agricultural products. It suggests a large increase in meat production and an advance in the rate of domestic consumption.

CATTLE.

The receipts of cattle at Chicago, Kansas City, St. Louis, and Omaha are more than three times as large as fifteen years ago, and have increased more than 70 per cent in five years. The increase exceeds 2,300,000, while the increase in exportation is only about 260,000, or including increase of meat exportation about 1,000,000 beeves, leaving nearly three fourths of the increase for home consumption. The total exports of 1889-'90, in beeves and beef, were little short of 1,000,000 animals, much above the average of our beeves in condition.

Receipts and shipments of Western markets.

Years.	Chicago.		St. Louis.		Kansas City.		Omaha.	
	Receipts.	Shipments.	Receipts.	Shipments.	Receipts.	Shipments.	Receipts.	Shipments.
1870	532,964	391,709	201,422	129,748	21,000	No record.	.....	.....
1875	920,843	696,534	335,742	216,701	174,754	126,262	.....	.....
1880	1,382,477	886,614	424,720	228,879	244,709	194,421	.....	.....
1885	1,905,518	744,093	386,320	233,249	506,627	402,381	114,163	83,233
1886	1,963,900	704,675	377,550	212,058	490,971	370,350	144,457	73,120
1887	2,382,008	791,483	464,828	277,419	669,224	483,372	235,723	151,419
1888	2,611,543	968,385	546,875	336,206	1,056,086	682,622	340,469	206,064
1889	3,023,281	1,259,971	508,190	297,879	1,220,343	744,510	467,340	227,921
1890	3,484,280	1,260,309	639,014	361,225	1,472,229	923,552	606,699	283,880

Comparing receipts and shipments, we find a decrease in the proportion of shipments, due to the great development of the dressed meat trade, which increases the proportion slaughtered in the West. The use of the refrigerator car has wrought a great change in the methods of transportation of meat, both to the Atlantic seaboard

and to Europe. The rapid increase of the entire movement is a suggestive fact in the history of our agriculture. The aggregates of these primary markets are as follows:

Years.	Receipts.	Shipments.	Years.	Receipts.	Shipments.
1870	755,386	521,457	1887	3,751,783	1,703,693
1875	1,431,339	1,039,497	1888	4,554,973	2,193,277
1880	2,051,906	1,309,914	1889	5,219,154	2,530,281
1885	2,912,628	1,462,956	1890	6,202,222	2,828,966
1886	2,976,878	1,361,103			

Receipts of Eastern cities.

Years.	New York.	Boston.	Philadelphia.	Baltimore.	Total.
1870	361,076	124,592	126,738	89,021	701,427
1875	457,057	145,285	152,830	112,679	867,851
1880	679,987	230,079	218,606	138,969	1,267,641
1885	562,447	112,995	194,644	90,870	960,956
1886	513,470	113,316	176,025	96,357	899,168
1887	498,048	99,584	122,297	85,166	796,495
1888	515,593	124,416	134,574	170,113	944,696
1889	638,937	167,342	150,482	205,479	1,162,240
1890	684,502	167,974	....	219,009	....

SHEEP.

The enlargement of the movement of sheep is also very rapid, indica'ing great increase in consumption, which is quite out of proportion to increment of population. The following statement is from the records of the four centers of distribution, Chicago, St. Louis, Kansas City, and Omaha:

Receipts and shipments of Western markets.

Years.	Chicago.		St. Louis.		Kansas City.		Omaha.	
	Receipts.	Shipments.	Receipts.	Shipments.	Receipts.	Shipments.	Receipts.	Shipments.
1870	349,853	116,711	94,477	11,649	....	....	....	....
1875	418,948	243,604	125,679	37,7[illegible]4	25,327	17,742	....	....
1880	335,810	156,510	205,969	93,522	50,611	36,285	....	....
1885	1,003,598	260,277	362,858	233,391	221,801	115,755	18,985	8,408
1886	1,008,790	266,912	328,985	202,728	172,659	83,234	40,195	17,728
1887	1,360,862	445,094	417,425	287,018	209,956	103,126	76,014	56,444
1888	1,515,014	601,241	456,669	316,676	351,050	169,932	158,503	118,208
1889	1,832,469	711,315	358,495	255,375	370,772	174,851	159,503	103,250
1890	2,182,667	929,854	358,506	252,151	535,869	336,207	156,186	94,464

The following are the aggregates of these records of receipts and shipments:

Years.	Receipts.	Shipments.	Years.	Receipts.	Shipments.
1870	444,330	128,360	1887	2,064,257	891,682
1875	569,954	299,130	1888	2,481,236	1,206,057
1880	592,390	286,317	1889	2,721,239	1,244,791
1885	1,607,242	617,831	1890	3,233,228	1,612,676
1886	1,550,629	570,602			

Receipts of Eastern cities.

Years.	New York.	Boston.	Philadelphia.	Baltimore.	Total.
1870	1,463,878	450,997	682,000	175,000	2,771,875
1875	1,233,968	372,370	491,500	191,485	2,289,323
1880	1,656,955	476,785	623,494	248,047	3,005,281
1885	1,849,277	639,847	616,573	178,712	3,284,409
1886	1,997,751	524,089	583,579	219,645	3,125,064
1887	2,025,116	591,476	588,279	227,456	3,432,327
1888	1,882,763	538,490	594,612	438,910	3,454,775
1889	1,805,805	540,460	537,431	421,951	3,305,647
1890	1,798,615	583,545	....	381,025	....

SWINE.

The effort in foreign countries to increase home supplies of swine, aided by tariffs and edicts of exclusion, has prevented the extension of our foreign trade, and for a time reduced its volume. The exports of 1889-'90 have nearly reached the highest limit of ten years ago. The record is as follows:

Receipts and shipments of Western markets.

Years.	Chicago.		St. Louis.		Kansas City.		Omaha.	
	Receipts.	Shipments.	Receipts.	Shipments.	Receipts.	Shipments.	Receipts.	Shipments.
1870	1,693,158	924,453	310,850	17,156	36,000	No record.	....	....
1875	3,912,110	1,582,643	628,569	126,729	63,350	15,790	....	....
1880	7,059,355	1,394,990	1,840,684	770,769	676,477	152,920	....	....
1885	6,937,535	1,797,446	1,455,535	789,487	2,358,718	801,162	130,867	71,919
1886	6,718,761	2,090,784	1,264,471	530,362	2,264,484	538,005	390,487	187,369
1887	5,470,952	1,812,001	1,052,240	324,745	2,423,262	524,492	1,011,706	140,726
1888	4,921,712	1,751,829	929,230	294,869	2,008,984	413,937	1,283,600	333,228
1889	5,988,526	1,786,659	1,120,930	420,310	2,073,910	331,434	1,206,605	179,916
1890	7,663,828	1,985,700	1,359,789	667,832	2,865,171	558,227	1,673,314	275,638

Years.	Receipts.	Shipments.	Years.	Receipts.	Shipments.
1870	346,850	17,156	1887	9,958,160	2,801,964
1875	4,604,029	1,725,162	1888	9,143,526	2,793,863
1880	9,576,516	2,318,679	1889	10,389,971	2,718,319
1885	10,882,655	3,460,014	1890	13,562,102	3,487,397
1886	10,638,203	3,346,520			

Receipts of Eastern cities.

Years.	New York.	Boston.	Philadelphia.	Baltimore.	Total.
1870	889,625	189,330	189,500	300,000	1,568,455
1875	1,388,517	331,989	243,300	279,631	2,243,437
1880	1,719,137	691,839	346,960	336,867	3,094,803
1885	1,919,063	790,332	326,456	265,381	3,301,232
1886	1,980,656	930,787	333,849	323,643	3,568,935
1887	1,791,531	1,039,692	329,561	504,619	3,665,403
1888	1,549,837	1,063,827	344,719	613,959	3,572,342
1889	1,761,623	1,143,314	401,424	702,966	4,009,327
1890	2,126,446	1,231,173	....	837,167	....

PROGRESS OF AMERICAN DAIRYING.

The only general enumeration of cows is that of the United States. A few of the States report assessors' returns, which are more or less complete. That of the United States includes only cows on farms, and not those in towns and villages. The real number of cows in the country is therefore the number returned by the census plus the number not on farms or ranches, and plus the omissions of the enumeration, which are probably not large in this case.

The census returns of product did not include milk sold in 1850 and 1860, and only butter and cheese made on the farm. Butter factories were then practically unknown, and cheese factories in process of organization, and not included in census schedules. The amount of milk sold for all purposes, from farms, was relatively small, yet some allowance should be made for it in comparing the dairy products, especially with reference to aggregate milk production of the census years.

In this comparison the butter and cheese are reduced to milk, on the basis of 3 gallons of milk to 1 pound of butter, and $1\frac{1}{6}$ gallons of milk to 1 pound of cheese. The best dairies do a little better than this, but the average of all, including farm dairies, is so near these figures that it is impracticable to make any reduction from them. Even in the New York dairy tests the churnings of selected dairies in the local conferences, which are really perambulating dairy schools, the averages range from 15 to more than 30 pounds, and in 1889 averaged 21.04 pounds. Selection and breeding have considerably reduced the ratio of milk to butter in the best dairies during the past thirty years, which, unfortunately, are in so small proportion to the whole number of cows that the general improvement is slow. The census records of butter and cheese are thus reported:

Years.	Butter.			Cheese.		
	Farm.	Factory.	Total.	Farm.	Factory.	Total.
1850	313,345,306		313,345,306	105,535,893		105,535,893
1860	459,681,372		459,681,372	103,663,927		103,663,927
1870	514,092,683		514,092,683	53,492,153	109,435,229	162,927,382
1880	777,250,287	29,421,784	806,672,071	27,272,489	215,885,361	243,157,850

Reducing the butter and cheese to milk, and adding 235,500,599 gallons of milk sold to factories and milk dealers, according to the census of 1870, and 530,129,755 gallons thus returned by the Tenth Census, the following aggregates of milk and averages per cow are obtained:

Years.	Cows.	Gallons of milk.	Gallons per cow.
1850	6,385,094	1,063,161,127	167
1860	8,585,735	1,499,985,364	175
1870	8,935,332	1,840,186,160	206
1880	12,443,120	2,893,698,520	233

These figures must not be received as the actual average yield of milk per cow, because the milk aggregate does not include that used

in the form of milk in the families of farmers. This factor in the problem can only be determined approximately. The proportion is smallest in the great dairy sections and largest in the States where butter and cheese are made in small quantities. In New York it has been estimated on the basis of the milk of one cow to each farm, which would give nearly the product of five cows for the markets to one for home consumption. As the dairy cows yield more than the farm cows, it might be fair to consider the ratio as six to one. On this basis the milk in products sold in New York in 1879 was equivalent to 401.6 gallons per cow, the milk used 66.9, making the total per cow 468.5 gallons. There should be a slight improvement in ten years in a portion of the stock, while there may be none in a much larger portion. Less than 2 per cent improvement would bring the average up to 475 gallons per cow, which is the maximum probability.

In some States, where cows are relatively few and the rates of yield small, at least two or three times as much milk is used in the natural form as is converted into butter and cheese. A definite estimate may not be practicable, but on the assumption that one fifth of the milk produced is consumed as such on the farm, the average yield per cow in 1880 would be about 291 gallons. This would make the milk product of farms 3,617,123,150 gallons. Add to this the milk of cows in villages and towns and the total probably exceeds 4,000,000,000 gallons. This refers to the milk of 1880. At the present time, with 16,000,000 to 17,000,000 cows—as there must be if all are counted—the aggregate milk produced undoubtedly approximates 5,000,000,000 gallons.

The prominence of a few States in dairying is presented strongly by the fact that ten States produce about two thirds of the butter and include more than half of the cows of the United States.

In the summary of products a remarkable change appears in cheese. In 1870 there was reported a product of 109,435,229 pounds, made in factories, in addition to 53,492,153 pounds made on farms. The farm product of 1860 was 103,663,927 pounds, which was all the cheese reported. In 1880 the farm product was still further reduced to 27,272,489 pounds, but the factory product was increased to 215,885,361.

In 1860 the factory system of cheese making, or associated dairying, began to attract general attention. Factories were in operation in Oneida County, New York. The system was originated by Jesse Williams, a farmer living near Rome in that county. He was an expert cheese maker and his product was eagerly sought by dealers, being far superior to the make of neighboring farms. The idea of the factory was accidental. Mr. Williams had contracted his cheese and that of his son, who had just entered upon dairying on another farm, at 7 cents per pound, a figure above the prevailing price. The son doubted his ability to make cheese of the desired quality, and it was finally arranged that he should bring his milk to his father's dairy. This suggested the thought that the neighbors might also bring their milk, which soon led to the erection of a factory building, and proved to be the pioneer of the cheese factories, which now represent the American system of coöperation in dairying. In 1854 a few more factories were built, and from two to four each succeeding year, until 1860, when seventeen were added to the twenty-one already in existence. In 1866 the number had increased to five hundred in New York, the larger number being built in 1863 and 1864.

As indicated heretofore, the census returned only butter and cheese in 1850 and 1860, the milk sold from farms being almost inappreciable in amount except in the vicinity of large cities. Since the rise

of associated dairying, the milk sold to factories, with that distributed for consumption in families, has added another item to the census count, that of milk sold. Reducing the butter and cheese to milk equivalents and adding milk sold, the milk produced per cow has been as follows:

States and Territories.	1880.		1870.		1860.		1850.	
	Number of cows.	Average yield per cow.	Number of cows.	Average yield per cow.	Number of cows.	Average yield per cow.	Number of cows.	Average yield per cow.
		Galls.		*Galls.*		*Galls.*		*Galls.*
Maine	150,845	314.2	139,259	270.2	147,314	252.3	133,556	228.9
New Hampshire	90,564	313.8	90,583	234.5	94,880	247.4	94,277	261.6
Vermont	217,033	387.3	180,285	349.5	174,667	328.0	146,128	318.8
Massachusetts	150,435	396.2	114,771	327.4	144,492	215.0	130,099	249.7
Rhode Island	21,460	323.0	18,806	258.6	19,700	166.3	18,698	179.5
Connecticut	116,319	325.4	98,889	290.9	98,877	277.2	55,461	301.3
Total	746,656	353.9	642,593	300.5	679,930	264.3	608,219	268.7
New York	1,437,855	401.6	1,350,661	358.2	1,123,634	325.7	931,324	319.3
New Jersey	152,078	289.9	133,331	226.6	138,818	233.1	118,736	243.8
Pennsylvania	854,156	322.8	706,437	280.6	673,547	265.6	530,224	231.1
Total	2,444,089	367.1	2,190,429	325.2	1,935,999	298.1	1,580,284	284.0
Delaware	27,284	247.9	24,082	177.5	22,595	190.3	19,248	164.7
Maryland	122,907	221.3	94,794	174.8	99,463	158.9	86,856	131.5
Virginia	243,061	147.0	188,471	113.0	330,713	123.1	317,619	106.3
Total	393,252	177.2	307,347	137.1	452,771	134.3	423,723	114.2
North Carolina	232,133	95.4	196,731	66.1	228,623	62.4	221,799	56.6
South Carolina	139,881	70.5	98,693	46.9	163,938	58.2	193,244	46.3
Georgia	315,073	72.0	231,310	58.9	299,688	54.5	334,223	41.8
Florida	42,174	26.2	61,922	4.9	92,974	13.3	72,876	15.6
Total	729,261	76.5	588,656	53.6	785,223	52.7	822,142	44.5
Alabama	271,443	89.4	170,640	57.1	230,537	78.5	227,791	53.0
Mississippi	268,178	85.0	173,899	45.2	207,646	72.4	214,231	61.0
Louisiana	146,454	20.6	102,076	17.8	129,662	33.5	105,576	19.4
Texas	606,176	71.0	428,048	26.3	601,540	29.7	217,811	32.8
Arkansas	249,407	95.1	128,959	64.3	171,003	71.5	93,151	60.1
Tennessee	303,900	180.3	243,197	120.5	249,514	121.1	250,456	98.3
Total	1,845,558	93.0	1,246,819	54.7	1,589,902	61.5	1,109,016	58.2
West Virginia	156,956	183.5	104,434	146.7	....	......	....	......
Kentucky	301,882	189.5	247,615	149.9	269,215	131.4	247,475	121.6
Ohio	767,043	328.8	654,390	279.0	676,585	252.5	544,499	234.4
Indiana	494,944	241.0	393,736	177.8	363,553	153.0	284,554	138.4
Illinois	865,913	239.7	640,321	186.5	522,634	165.2	294,671	132.6
Total	2,586,738	257.1	2,040,496	208.0	1,831,987	190.0	1,371,199	172.2
Michigan	384,578	324.7	250,859	304.0	179,543	269.7	99,676	224.5
Wisconsin	478,374	267.3	308,377	231.3	203,001	207.5	64,339	176.7
Minnesota	275,545	216.3	121,467	239.1	40,344	225.7	607	5.4
Total	1,138,497	274.4	680,703	259.5	422,888	235.7	164,622	205.0
Iowa	854,187	215.0	369,811	228.5	189,802	194.6	45,704	147.9
Missouri	661,405	134.9	398,515	111.6	345,243	111.3	230,169	103.1
Kansas	418,333	160.0	123,440	125.8	28,550	116.1	....	......
Nebraska	161,187	186.6	28,940	164.7	6,995	149.0	....	......
Colorado	28,770	107.8	25,017	49.5	....	......	....	......
Total	2,123,882	175.6	945,723	159.1	570,590	139.7	275,873	110.6
California	210,078	274.2	164,093	192.4	205,407	52.8	4,280	0.5
Oregon	59,549	129.9	48,325	92.2	53,170	58.7	9,427	71.9
Washington	27,622	160.1	16,938	74.6	9,660	49.0	....	......
Nevada	13,319	88.3	6,174	64.2	947	24.4	....	......
Total	310,568	228.4	235,530	160.0	269,184	54.0	13,707	49.6

States and Territories.	1880.		1870.		1860.		1850.	
	Number of cows.	Average yield per cow.	Number of cows.	Average yield per cow.	Number of cows.	Average yield per cow.	Number of cows.	Average yield per cow.
		Galls.		*Galls.*		*Galls.*		*Galls.*
Arizona	9,156	27.2	938	25.7				
Dakota	40,572	159.3	4,151	152.1	286	22.8		
District of Columbia	1,292	433.1	657	212.4	639	88.4	813	57.0
Idaho	12,838	75.7	4,171	84.1				
Montana	11,308	116.5	12,432	109.3				
New Mexico	12,955	12.1	16,417	4.3	34,369	2.4	10,635	0.7
Utah	32,768	105.6	17,563	58.3	11,967	84.4	4,861	58.9
Wyoming	3,730	106.1	707	12.1				
Total	124,619	108.9	57,036	63.3	47,261	24.5	16,309	20.8
Grand total	12,443,120	232.5	8,935,332	205.9	8,585,735	174.7	6,385,094	166.5

In examining this table it should not be forgotten that the milk used as such on farms is not included. This might be, in New York, one sixth as much as that manufactured and sold, and in some of the non-dairying States a still larger proportion than that manufactured and sold. After making all possible allowances, there will still be a great difference between the yields of different States, ranging from 470 gallons in New York to less than 170 gallons in some of the Southern States.

It is a noticeable feature of this table that the yield increases from decade to decade. It is evident that the advance is not due entirely to the increasing accuracy of the returns, or to the milk sold introduced into the later enumerations. The attention given to selection and breeding has increased the rate of yield, and to some extent the proportion of butter-fats. The relation of milk to butter varies widely in different breeds, and in individual cows of the same breed. The experience of Hon. Zadoc Pratt, thirty years ago, affords a good illustration of this fact, and of the low average butter yield of the unimproved farm cows of that period. His farm was a large one of 365 acres, formed originally from hemlock clearings among the hills of the northwest corner of Greene County, near Delaware. In 1857, with selected cows averaging 636 gallons, the average milk to 1 pound of butter was 39.2 pounds. He saw the necessity of getting cows with richer milk, and his average was 32.33 to 1 the next year, and 29 in the year following. In 1860 the ratio was 23.3 to 1, and in following years successively 21, 19.7, and 20 pounds. The quantity of milk per annum was slightly reduced, but the yield of butter was nearly doubled.

The most hopeful and promising effort looking to practical results in the education of the future butter makers of the farm is the modern dairy school. New York has instituted a series of "dairy conferences," which continued last year through the summer, from May 30 to November 15, under the instruction of Messrs. W. H. Gilbert, F. D. Curtis, E. S. Munson, and H. Cooley Greene. There were twenty-nine meetings held, at which two or three examples of butter making were given, with rarely less than 200 pounds of milk at each, 69 churnings averaging 319 pounds, and yielding 1 pound of butter to every 21.04 pounds of milk. Many important points are illustrated by these ever-varying results. The wide differences in butter yield of different dairies, of different breeds of cows, and in

individuals of the same breed are illustrated distinctly and impressively in these tests. The great disparity in time required for churning, the various temperatures of the milk in creaming and of the cream in churning, the implements and appliances for setting the milk, the rations fed and methods of feeding, furnish themes for discussion and originate suggestions for thought and study, and lead to questions not easily answered and problems of science and practice not readily solved.

When such a series of conferences includes a churning which produces a pound of butter for less than 13 pounds of milk, while another requires more than 32 pounds of milk to make one of butter, it suggests in the latter case the prompt services of a butcher or the ultimate necessity for a mortgage or a sheriff's sale. As might be expected, the Jerseys led in butter product; six of the churnings were of pure Jersey milk, one producing a pound of butter for 12.77 pounds of milk and another a pound for 19.5 pounds, the average being 15.88 pounds. The Jersey grades were nearly as good, in only one instance a low grade requiring 20 pounds, and in one case less than 15 pounds. The natives were variable, some of them excellent, one requiring only 19 pounds, while one required 32 pounds. It is costly ignorance which feeds and milks and shelters two cows without knowing that more butter can be produced at the cost and care of one.

These dairy schools should offer to every ambitious boy and girl of the farm dairy a practical and ample curriculum of economic science. They are as yet only germs of the good of which they are capable when enlarged and perfected as they may be in the future.

THE DOMESTIC FOOD SUPPLY.

Relative to the prospective food supply there are two classes of extremists, optimists and pessimists, each enforcing conclusions by statistics. One maintains the theory of the possibility of practically unlimited food production, and the desirability, both from pecuniary and philanthropic considerations, of "feeding the nations of the world," thus preventing a glut in our own markets and such a fall in prices as to destroy all profit in production. The other claims that consumption is overtaking production, and will soon require foreign aid in maintaining supplies. Now in certain products in years of abundant yield, there has been such a surplus as to render unprofitable the labor of cultivation, and at the same time there has been an insufficient supply of other food products always grown here, and a failure to produce still others which might be, and which are now imported. So there is a color for each claim. But a broad statement of either view is unsupported by the logic of current agricultural statistics.

It is easy to draw hasty conclusions from such statistics, especially from the extraordinary data of the past thirty years, which are sure to prove unreliable and misleading. The abnormal demand arising amid civil war; the impelling force of high values during the cotton famine in pushing the extension of cotton area; the inflation of a subsequent period, ending in collapse; the remarkable era of cereal dearth in Western Europe; all these and other influences tended to general increase of product, with occasional fluctuations. Hence it has been easy to draw deductions which the facts of the future can

not be depended on to sustain. Twenty-one years ago veteran planters maintained in elaborate argument that 3,000,000 bales of cotton could never again be grown, but the fact refuted the prophecy in a single year, and the product has now passed 7,000,000 for several years. Others insist that the limit of area and product of wheat has been reached, because the breadth of nearly 40,000,000 acres of six years ago has not been maintained, and the product of 1890 is scarcely four fifths as much as that of 1884. The fact is too easily forgotton that areas fluctuate in obedience to changes of value; that flocks are slaughtered while herds are enlarged, and *vice versa*, as prices of meat and wool go up or down. One can with difficulty foretell what may happen in American agriculture, even when he knows all the circumstances which shall affect its results. The comparative stability of crop areas and rotations of some European countries is not to be expected in the United States, where rotation is almost unknown, and prospective profit controls the annual distribution. This fact injects an element of difficulty and uncertainty into statistics of agriculture.

While the public land areas are greatly reduced, and the proportion of improved lands of the older States is larger than ever, it is perfectly safe to assume that there is no ground for the pessimistic theory that our lands have all been taken up, that fertility is declining, that cultivation can not be extended, and foreign aid must be sought to meet the wants of advancing population.

The old tale of the wheat movement westward, as a sort of John Gilpin cereal race for the goal of the Pacific coast, with the Genesee Valley as a starting point, has been told and retold, though it has no more point now than when it was first presented. The sole meaning of the movement is that the pioneers of agricultural settlement have been wheat growers, and exclusive wheat growing has been the advance guard of agricultural forces in this country, keeping even step with progressive movement along the westering path of settlement. The country left behind grows as much wheat as before, the country nearest sunset grows all the more, and so the rapidly increasing aggregate is made to meet the wants of advancing population. The old area requires variety in cropping, and, if held by an intelligent yeomanry, gains in fertility by rotation and fertilization; the new must be subdued with the least labor and capital, a requirement which is met by wheat, a cash crop, which bears transportation better than any other cereal product. This explains why the center of wheat growing has moved gradually westward until it has reached the Mississippi River, but it does not prove that the soil is exhausted, that the area of Eastern productive land has reached its limit, that the rate of yield of farm products has attained its maximum, or that farming can no longer be profitable east of the Mississippi. More of the Eastern farm land will be made productive, and larger yields will be obtained by higher skill and more scientific methods.

The scale of living of farmers and others has been greatly advanced during the past fifty years. The supply of wheat in proportion to population has been nearly or quite doubled, some of it exported, but also much more consumed per head than formerly. In 1849 the production was 4.33 bushels per head; in 1879 (and again in 1884), 9.16 bushels. The increase of population in this period of thirty-five years was about 140 per cent, while the increase in wheat production was 410 per cent. This was abnormal, in part due to temporary demand of extraordinary proportions. It will not do to base

deductions of future wheat production upon irregular and unusual data; nor, on the other hand, is it safe to assume that our farmers will not supply a liberal domestic demand for a long time to come.

Corn, as a native American product, of nearly universal distribution, has always been in great abundance and wastefully profuse in consumption, yet the average per head of 25.5 bushels in 1849, has been increased, and in medium to abundant years averages from 30 to 33 bushels per head. As the exportation averages only 1 bushel in 25, the rate of consumption has materially increased.

So with many other products, meats especially. With an increase of rate of population that has excited the wonder of the world, there has been a material advance in consumption of food products and a corresponding increase in that of clothing. The following extracts from a nonofficial exposition of this question by the Statistician will throw further light upon this subject:

In the use of food our people are profuse and even wasteful. All classes use meats freely, ordinarily three times daily. A great variety of fish, oysters that have a fame extending beyond seas, and various forms of the crustacea enrich the national dietary. According to accepted statistics Great Britain consumes an average meat ratio not over two thirds as large as the American, France scarcely half as large, Germany, Austria, and Italy still less.

The American negro, even in the days of slavery, was usually allowed a weekly ration of 3 pounds of bacon and a peck of meal, besides vegetables and other products either of the plantation or his own garden patch. This made at least 150 pounds per annum, not to mention the occasional opossum and chicken that were respectively his legitimate game and his illegitimate plunder; and this amount of meat is more than the average consumption of any European nation, and two or three times as much as the average ration of several of them, including with the peasant and artisan, the citizen and nobility.

The average consumption of meat in the United States is probably not less than 175 pounds per annum. Of other civilized nations only Great Britain exceeds 100, and many of them scarcely average 50 pounds. The consumption of the cereals, by man and beast, is three times as much, in proportion to population, as in Europe. For the past ten years the average has been 45 bushels for each unit of population, while the usual European consumption does not vary greatly from 16 bushels per annum. While all is not used as food for man, no small part of it contributes to the meat supply.

The average consumption of wheat for bread is nearly 5 bushels, and about 3 bushels of maize and 1 bushel of oats and rye, or approximately 9 bushels for each inhabitant. The average European consumption of wheat is about 3.5 bushels. In the consumption of fruits the difference between this and other countries is marked with unusual emphasis. Small fruits, orchard fruits of all kinds, and tropical fruits, as well as melons of many varieties, are in profuse and universal daily use in cities and towns, and in the country the kinds locally cultivated are still cheaper and more abundant in their respective localities, though scarce in the regions of recent settlement and those unsuited to a wide range of species.

The consumption of vegetables is not excessive. The products that are rarest and dearest are those which are advancing in relative prominence in the dietary of the people. Variety and quality in food products are the points in which progress has been continuous and extensive. Not unfrequently skilled mechanics or miners, making high wages, are more fastidious and profuse in their marketing than citizens living upon the profits of capital. The abundance and variety of every form of food production, and the general distribution of means for procuring it lead to profusion and tend to wastefulness.

The American people are no less profuse in clothing than in food. This country is a favored land in fiber production. More than $400,000,000 is the comfortable sum which represents the present fiber products, in the form of cotton, wool, hemp, and flax. There is also experimental production of silk, ramie, sisal, jute, and many others suited to the climate, some of which will ultimately become the foundation of industries.

More than half of the material for the cotton factories of the world is grown here, and a third of that is manufactured and mostly consumed at home. If 65,000,000 people require one sixth of the cotton manufactured in Europe and America for the use of nearly 450,000,000 inhabitants of these continents, and of the millions in

India, China, Japan, and other countries obtaining supplies from the factories of Christendom, the disparity in consumption between this and other countries must be great indeed.

With an average per capita consumption of 17.5 pounds of cotton, 8.5 of wool, and a large quantity of silk, linen, and other fibers, the claim of superiority in supply of clothing can not well be disputed. Thus one twentieth of the population of the world consumes nearly a fourth of the wool product of the world. If the people of Europe should demand an equally liberal supply the earth might be scoured in vain for the requirements of such a consumption. As they do not, it may be supposed that a larger proportion of cotton would be needed; but a consumption equal to that of this country would not leave a pound for North or South America, Asia, Australasia, or Oceanica.* Indeed it would not suffice for more than a supply of 15 pounds per head to Europe alone.

Can this supply be kept up, or is the pressure of population on subsistence about to manifest itself? It would be a disgraceful imputation upon our agriculture to admit it. Scarcely more than a third of the South is included in farms, and the proportion of farm land in Maine is no larger. The land in the West is not all taken, and an immense area of arid lands can be irrigated and made highly productive. Then a considerable area of farm lands is not now utilized in production, and much of the tilled land is not half cultivated. High culture upon a scientific and common sense basis might increase materially if not double the present rate of yield. It will be time enough to talk of importation of food products when our population is five times as large as at present. The following extract further enlarges upon this theme:

With 9,000,000 farmers and farm laborers, cultivating over 5,000,000 farms, but a third of the land is taken up, but a small part of that is under crops, and the area under nominal cultivation is superficially treated and scarcely up to half its maximum production. There is nothing surprising in this. Cultivation is always primitive where land is cheap, before land speculation gives place to scientific agriculture. For this reason the richest lands are often found to give the lowest yields; for this reason the average wheat yields of the prairies of Iowa are less per acre than those of the granite hills of the East.

WAGES OF FARM LABOR.

It was thought possible that the wages of farm labor might be affected somewhat by the low prices of certain farm products—of corn and oats especially. This investigation is made in the spring, usually once in three years, but it was deemed advisable, on account of the complaints of low prices and hard times, to make the inquiry in 1890, though the previous one was instituted in 1888, and thus ascertain what effort, if any, had resulted in reduction of the rate of wages of labor.

The investigation showed no material decline in wages. Employers generally insisted that they were too high, and in many instances the tendency to reduce the amount of service was indicated; yet there was very little actual reduction, by no means enough to affect perceptibly the farm labor market. It is evident that the industries of the country are still in a comparatively prosperous condition, and that there is not a very large proportion of labor unemployed. Everywhere there is a pressure of competition with farm labor, withdrawing laborers from rural engagements and leaving to the remainder fair wages. In some places farmers complain that

* Ellison in his "Cotton Trade," makes the average weight of cotton goods consumed annually 5.68 per head. Belgium uses 9.8 pounds; Great Britain, 7.56; Germany, 7.53; Austria, 5.27; Italy, 5.06; Russia, 3.31, etc.

the more intelligent and skilled are withdrawn, and that they are compelled to pay higher wages than they can afford.

Farm wages in New England are slightly advanced as compared with the rates two years ago. Farm laborers prefer to go to the cities and find employment in cotton factories, machine works, shoe shops, or in other business. In northern districts lumbering, the ice business, and shipbuilding on the coast compete with farm work. There is much complaint of scarcity of intelligent labor.

Some report an abundance of foreign labor, which is characterized by many as unreliable. Laborers of this class require too much instruction and supervision.

In New York a similar scarcity exists. In some districts it is estimated that laborers obtain about one third more wages in other trades. This is natural and equitable, as the expenses of living are higher in towns. Farmers try to do their work with as little hired labor as possible, to avoid the expense of skilled labor and the annoyance of unskilled. They say that a majority of the laborers are looking for an "easy job." The demand for labor on railroads, at the oil wells, cement works, and in factories withdraws the more efficient laborers from the farms.

In New Jersey the usual manufacturing demand for labor is supplemented by the requirements of railroads, of watering places, of the oyster and clam business, and that of various fisheries.

Various causes of scarcity prevail in Pennsylvania. The coal and oil regions compete strongly, as do the furnaces and rolling mills, sawmills, bark mills, and various lumbering operations. Farmers say they can not afford to pay the wages which labor commands in these industries. Of course the feeding of the multitude otherwise makes a better demand and higher prices for agricultural products, with the limitation of the pressure of Western competition in the staples that can be readily transported long distances. Not a few counties, however, report a supply of labor equal to the demand.

In Delaware and Maryland there is also competition from factories, and from the oyster business on the eastern shore of Maryland, and from lumbering in the western mountain area. The Howard correspondent says: "It is abundant, but more worthless every year."

It is gratifying to note the activity of the demand for labor in mining and manufacturing, fisheries, and other industries, which has increased the rate of wages in Virginia, and made a demand for farm products. In some counties there is still a supply of farm laborers. In others a scarcity is noted. The tendency among young colored men to seek summer employment in Northern States is noted. Some farmers complain of its cost and decry its efficiency.

In the cotton States very few laborers are employed during the year at given rates in money. Those working on plantations prefer to work at shares of produce, under contracts greatly varying in terms. On the Atlantic coast there is a tendency to emigration westward, and also to working on shares. The turpentine business is moving down the coast and westward, causing the removal of able-bodied men from North Carolina, while those who remain, sometimes the women left behind, attempt to carry on farms, often running into debt with disastrous results. In South Carolina railroad enterprises and phosphate mining attract labor by higher remuneration. There is evidence of increased demand for labor in Georgia, Alabama, and Tennessee, in iron and coal mining, in fur-

naces and factories, and in other enterprises. It is an unusual experience, in the previous history of industry in Alabama, which the Hale correspondent indicates, "Most able-bodied men are working in mines, furnaces, and on railroads."

In one instance the abundant crop of last year is charged with producing a scarcity of labor, because while the means of the laborers hold out they will not work on farms.

In Mississippi there is in general a good demand for labor, as young white men leave the farms and become teachers or engage in mercantile pursuits, and colored laborers go to Louisiana or Texas, or to the swamp region, from the settled portions of the State. In the parish of St. Mary, Louisiana, labor is abundant and reliable, a good feeling existing between them and their employés. Labor is generally reported scarce in Texas, as the laborers wish to cultivate land of their own, either plantations cut up and leased on shares, or cheap lands in the western part of the State. In some parts of Texas it is said that farmers are "too hard pressed for money to have help," and that they "can not afford to borrow money at 10 to 12 per cent to pay for hired help." Labor here is augmented by immigration of Bohemians and Germans.

In Western Texas many Mexicans are employed. Much land is unoccupied in parts of Texas for want of labor to cultivate it. One correspondent refers to the negro as the best cotton maker, but indolent and content with a bare living. In Kaufman County "thousands of acres will be uncultivated this year from scarcity of hands." This scarcity and low prices have so discouraged farmers that they have mortgaged their farms to loan companies or abandoned them. There is a fruitful region in Arkansas, where labor is abundant, because the "small farms have more boys than tillable land or horses." Throughout the South it is easier to find transient or temporary labor, day labor, than regular employment by the month throughout the year.

Labor is somewhat scarce in West Virginia, owing to the activity of lumbering and coal-mining operations. In some counties in Kentucky labor is abundant, in others scarce, where laborers have gone into other industries. There is some complaint of lack of reliability.

There is abundance of work and plenty of workers in Ohio. The central county, Franklin, reports that "every man in the county can have work every day if he chooses." Yet there are local suggestions of deficiency as well as of abundance. It is held by some that from the farmer's standpoint, in view of the prices of products, farm labor is too high.

Many reporters in the West think wages are higher than the results of farming warrant, and that consequently farmers employ no more help than is absolutely necessary. There is in most places no real scarcity, yet a good demand exists, stimulated by competition, in lumbering, coal mining, railroading, and in the various industries of cities. Good help is scarcer than poor in the West as everywhere else. There is no difficulty in finding employment at fair wages for all skilled labor throughout the central valley region. In parts of Wisconsin the influx of Germans, Swedes, and Norwegians causes a superabundance of labor. One correspondent in Minnesota refers to the interesting fact that farmers' sons occupy their own land and thus reduce the demand for hired laborers. The self-binder has been a great boon in the harvesting of wheat, enabling the grower to do his work with fewer harvest hands. In many places farmers "change

work" with their neighbors, combining their forces for harvest work, and with the aid of their machines avoiding the employment of harvesters by the day. This has reduced the excessive wages formerly demanded by harvesters in the great wheat regions. In Howard County, Missouri, a superabundance of colored laborers is reported, who will not work on farms, and it is claimed that "a thousand good, honest white men and women can find pleasant homes at remunerative wages."

On the Pacific coast the use of farm machinery is reducing the number of laborers employed, and the rate of wages, though still higher than in other States, has been materially reduced. There seems to be a tendency towards ownership of land by laborers, which is reducing the number employed. There is considerable immigration into Oregon, which increases the supply of labor there. Labor is fully employed in the Rocky Mountain region and in some places it is scarce. There is great activity in business of all kinds in the arid region and great promise of future development.

The result of the whole investigation indicates a fair, if not full, employment of farm labor, at wages substantially the same as two years ago. It is suggestive and hopeful to note the increase of industrial activity in the South and West, more general and various than ever before, not only employing surplus rural labor, but making demand for the products of agriculture where they are grown. There is complaint of low prices of corn and oats, and thence in less degree of pork products, but wheat is higher than two years ago and meats about the same as at the former investigation. A bad season, which would reduce the corn crop 30 per cent, would increase its price 40 or more, and of oats nearly as much. The depression, therefore, is only partial and probably temporary, and has not reduced wages of farm labor, partly because there is still a firm demand for the best quality, and partly because of the general industrial prosperity, which has a favorable reflex influence upon agriculture.

The sectional averages for each period of investigation are as follows:

Sections.	1890.	1888.	1885.	1882.	1879.	1875.	1869.	1866.
Eastern States	$26.64	$26.03	$25.30	$26.61	$20.21	$28.96	$32.08	$33.30
Middle States	23.62	23.11	23.19	22.24	19.69	26.02	28.02	30.07
Southern States	14.77	14.54	14.27	15.30	13.31	16.22	17.71	16.00
Western States	22.00	22.22	22.26	23.63	20.38	23.60	27.01	28.91
California	35.50	38.08	38.75	38.25	41.00	44.50	46.38	35.75
Average, United States	18.33	18.24	17.97	18.94	16.42	19.87	....	....

There have been only slight fluctuations in the average rates of wages since 1879, the period of lowest depression, which followed an era of currency expansion, speculation, and nominal high prices. Leaving out the Southern States, where negro labor depresses the average, the average rate would be $23, which represents the wages of white labor more truly than the general average of the country.

WAGES PER MONTH BY THE YEAR.

The results of seven investigations, occurring at intervals between 1869 and 1890, are presented together in the following table, in which

the changes of twenty-one years in monthly wages are shown at a glance:

[Wages given in dollars.]

States and Territories.	1890.		1888.		1885.		1882.		1879.		1875.		1869.	
	Without board.	With board.	Without board.	With board.	Without board.	With board.	Without board.	With board.	Without board.	With board.	Without board.	With board.	Without board.	With board.
Maine	25.00	17.50	24.64	17.20	23.09	16.00	24.75	16.15	18.25	11.08	25.40	15.94	26.25	16.50
New Hampshire	25.15	17.60	24.38	17.00	22.80	15.75	25.25	16.72	19.75	12.30	28.57	18.25	32.66	22.16
Vermont	24.80	17.35	23.25	16.40	23.00	16.20	23.37	16.00	19.00	11.50	29.67	19.37	32.40	21.40
Massachusetts	30.00	18.50	29.50	18.00	28.75	17.85	30.66	18.25	25.00	15.33	31.87	20.25	35.95	22.16
Rhode Island	29.20	18.00	27.75	17.50	28.50	17.70	27.75	17.00	23.00	13.25	30.00	19.00	32.25	20.00
Connecticut	27.00	17.33	27.40	17.17	27.67	17.20	27.90	17.37	23.29	14.23	28.25	18.50	33.00	20.75
New York	24.45	16.65	24.13	16.30	24.00	16.52	23.63	15.36	20.61	13.19	27.14	17.80	29.28	18.64
New Jersey	25.10	16.00	23.33	15.73	23.60	14.10	24.25	14.20	20.22	11.53	30.71	16.78	32.11	19.02
Pennsylvania	22.80	14.60	22.24	14.50	22.52	14.12	22.88	14.21	19.92	11.46	25.89	16.10	28.68	18.05
Delaware	17.35	11.15	18.00	12.25	18.33	12.63	18.20	12.50	17.00	9.50	20.33	11.67	22.00	13.00
Maryland	17.67	11.25	18.48	11.84	18.20	11.50	16.34	9.89	14.00	8.95	20.02	11.42	21.55	12.00
Virginia	14.21	9.47	18.32	9.25	13.95	9.34	13.96	9.17	11.00	7.66	14.84	9.21	15.28	9.65
North Carolina	12.83	8.80	13.41	9.00	12.85	8.91	12.86	8.80	11.19	7.66	13.46	8.82	12.76	7.91
South Carolina	12.10	8.62	12.25	8.00	12.00	8.25	12.10	8.10	10.25	6.66	12.84	8.19	11.54	7.34
Georgia	13.13	8.37	12.60	8.81	12.47	8.73	12.86	8.70	10.73	7.38	14.40	8.79	14.70	9.70
Florida	19.35	12.59	18.00	11.33	17.80	11.37	16.64	10.20	13.80	8.73	15.50	10.75	16.10	10.91
Alabama	14.00	9.85	13.59	9.49	13.00	9.10	13.15	9.09	13.20	8.30	13.60	9.40	15.19	10.52
Mississippi	15.38	10.50	15.03	10.09	14.60	10.00	15.10	10.09	13.31	9.28	16.40	11.25	17.11	11.21
Louisiana	15.98	11.79	15.37	11.12	16.05	11.26	18.20	12.69	16.40	11.27	18.40	12.20	21.37	12.62
Texas	19.85	13.30	19.20	12.60	18.87	13.72	20.20	14.03	18.27	11.49	19.50	13.37	18.83	13.21
Arkansas	18.40	12.55	18.34	12.50	17.33	12.25	18.50	12.25	17.12	11.31	20.50	13.00	25.25	16.60
Tennessee	14.23	10.12	14.00	10.00	13.88	9.74	13.75	9.49	12.73	8.69	15.20	10.00	16.81	11.00
West Virginia	19.55	12.95	18.74	12.25	19.00	12.40	19.16	12.46	16.98	10.94	20.75	13.10	21.39	13.87
Kentucky	16.85	11.70	16.51	11.33	16.80	11.69	18.20	11.75	15.17	10.00	18.12	12.00	18.84	12.57
Ohio	22.10	15.10	22.21	15.00	23.00	15.50	24.55	16.30	20.72	13.34	24.05	16.33	26.35	16.74
Michigan	24.80	16.75	25.20	17.00	24.00	16.14	25.76	17.27	22.88	14.64	28.22	18.46	31.01	20.03
Indiana	22.25	14.78	22.50	15.30	22.20	15.30	23.14	15.65	20.20	12.76	24.20	16.14	25.42	17.03
Illinois	23.25	16.35	23.20	16.00	23.50	16.60	23.91	17.14	20.61	13.01	25.20	16.87	27.22	17.69
Wisconsin	24.35	16.75	24.65	16.80	23.54	16.78	26.21	17.90	21.07	13.81	25.50	16.45	30.08	18.47
Minnesota	24.60	16.60	25.75	17.68	25.50	16.75	26.36	17.75	24.55	15.62	26.16	16.36	28.61	17.94
Iowa	25.41	17.00	25.60	17.34	25.33	17.00	26.21	17.95	22.09	13.90	24.35	16.11	28.39	17.87
Missouri	20.25	14.00	21.00	14.20	21.35	14.50	22.39	13.95	17.59	11.84	19.40	13.15	24.47	16.38
Kansas	22.75	15.05	24.25	16.05	24.70	16.00	23.85	15.87	20.67	13.28	23.20	14.65	28.96	18.38
Nebraska	25.50	16.60	25.59	17.18	25.00	16.50	24.45	16.20	23.04	14.86	24.00	14.75	33.25	19.18
California	35.50	22.40	38.08	25.67	38.75	25.00	38.25	23.45	41.00	26.27	44.50	28.60	46.38	28.69
Oregon	31.60	22.00	32.56	23.00	34.00	21.25	33.50	24.75	35.45	23.86	38.25	25.67	....	....
Nevada	35.00	23.00	38.00	27.00	....	....	....	....	....	....	....	....	....	....
Colorado	33.75	21.00	36.00	23.00	33.00	21.25	36.50	27.08	35.00	20.00	38.50	21.14	....	....
Arizona	33.00	21.50	25.00	16.00	....	....	....	....	....	....	....	....	....	....
Dakota	24.75	17.10	25.85	18.21	25.55	17.60	....	....	28.56	16.57	32.50	20.50	....	....
Idaho	36.25	23.50	39.00	26.25	....	....	....	....	....	....	....	....	....	....
Montana	36.50	23.80	40.00	27.50	....	....	....	....	....	....	....	....	....	....
New Mexico	27.50	17.83	28.75	18.25	28.75	17.50	....	....	22.10	13.80	22.75	14.25	....	....
Utah	32.30	21.00	33.50	22.30	30.00	21.00	....	....	28.87	20.50	35.50	25.33	....	....
Washington	37.00	24.40	35.20	25.00	38.33	26.25	....	....	....	....	....	....	....	....
Wyoming	34.00	23.00	37.00	25.00	....	....	....	....	....	....	....	....	....	....
Average	18.33	12.45	18.24	12.36	17.97	....	18.94	....	16.42	....	19.87	....	....	....

FLUCTUATION OF AGRICULTURAL PRICES.

A statistical analysis of prices of farm products for twenty or thirty years does not warrant the idea that prices have suddenly declined, are much lower than formerly, or in unexampled depression. The tables of quotations of various products show great fluctuation, low rates in abundant years, high values in years of scarcity. The idea somewhat prevalent of a strong tendency to continuous decline is not sustained by the record. The downward tendency of prices of farm products during thirty years has been far less conspicuous than the decline of values of other products of human labor. This applies to

farm products as a whole, rather than selected crops and exceptional years.

To specify principal crops, corn for ten years, average farm value, has been about 40 cents per bushel. From 1870 to 1879 it was only 2 to 3 cents more, and in gold value no higher than for the recent decade. Even in the decade from 1860 it was no higher in gold. But fluctuations occur in each period, as in the last, when 28.3 and 63.6 cents represent the value of largest and smallest crops respectively. The prices of wheat have been higher for three years past than for the three preceding. From 1876 to 1880 they were much higher from the unexampled demand due to the crop failures of Western Europe. The average of Chicago prices for three decades, expressed in currency, are nearly the same in gold for each, though there are annual fluctuations. The export price of cotton for the last fiscal year was about 10 cents per pound, while the average for ten years is only 10.5 cents per pound. Prices during the civil war were of course higher. The current rate depends entirely on the quantity marketed. Beeves are within two or three points of the prices of the last five years, the price of wool is advancing, fruits and vegetables command usual prices, higher if scarce and lower if abundant. The sellers get all they can for their share, as usual, and have facilities for combination to enforce their demands, which are not perceptibly greater than for several years past.

Thus we find nothing in the prices of farm products, either current quotations or their course and tendency in recent years, to warrant the assumed existence of any sudden, extraordinary, or permanent fall in values of farm products. We find that some are higher than they have been and still improving; that the national crop, corn, which has been plethoric in quantity, and therefore low in value, is higher than at any time since 1881; that hereafter, as heretofore, demand will control price, and the grower who caters to a new and rising demand, grows some product of which there is no surfeit, will obtain a more generous remuneration for his labor. Foresight in this matter, a wise departure from the conservatism of routine, and aptitude for deftness and skill in new lines of effort, will bring better prices and better times.

THE PRICE OF CORN.

The fluctuation in the price of corn has been great. It is not difficult to account for it. Prices depend on supply. With a variation in the supply of 12 bushels per head, or from 23 to 35 bushels, it is not strange that the average farm price should be 63.6 per bushel in one case and 28.3 in the other. In extreme scarcity the advance in price is out of proportion to the decline in supply. A fall of 522 million bushels in 1881 sent the price up 24 cents per bushel. An increase of 422 million bushels the next year caused a fall of 15 cents. It would have gone lower but for the exhaustion of old corn during the previous year. The next crop, nearly as large, averaged 6 cents less, and with increase of product in the two succeeding years the value declined 10 cents, and again rose 12 cents in two more years in consequence of successive diminutions of product. Then came the two largest crops ever grown, depressing the value, first from 44.4 to 34.1, and then to 28.3. Succeeding this is the present crop of only 24 bushels per head, causing a jump to 50.6 cents, an increase of 77 per cent. What more is needed to show that with crops small

enough the highest prices ever known can be obtained without the slightest influence of the assumed tendency of the time to low prices?

The largest supply was in 1879, 1885, and 1889. In the former year the largest exportation ever known in corn and cornmeal and in pork products (to supply an alarming deficiency in Western Europe) aided in advancing the price heavily. In the latter two the values were 32.8 and 28.3, the lowest of the list, yet not equally depressed, for one reason because of the large production of oats in 1888 and 1889, which is a crop that supplements corn and influences its price.

Going to the other extreme, that of the highest price, 63.6 cents in 1881, the smallest crop of the period is found, about half that of 1889 in absolute quantity, but seven tenths as much in proportion to population. The supply per head was lowest at this time, and was apparently but little higher in 1887, when the price was only 44.4 cents, but really the quantity for home consumption was much greater, because the foreign exports of corn and pork products were so much reduced, leaving a larger supply for home use. Could the exports of grain and secondary products be eliminated from this supply per head, and the remainder of each year be incorporated with the next crop, the relation between quantity and price would be still more striking, leaving little allowance for other causes affecting prices. It is with corn as with wheat, prices were reduced by keeping up the relative supply, while the exports have fallen off. For five years the supply per head has been larger than for the previous five years, while the proportion exported as grain and pork and lard has been less. A continuous oversupply, though the excess be small, suffices to glut and demoralize the market.

The average requirement, while exceedingly flexible, because depending so much on the abundance of other feeding material, must be taken to be about 27 bushels to each unit of population. Perhaps the actual supply has been near 28 bushels, exclusive of exports. The average farm price for ten years has been 39.3 cents per bushel and for the preceding decade 42.6 cents.

Commercial prices in Chicago may be found on another page for the 1st of January in each year since 1860. Dividing into periods of ten years, and making a rough average of these January prices, a comparison can be made. The first period has an average of 56.3 cents per bushel, the second 43.6 cents, and the third 42.8 cents. The Chicago average for the last ten years is thus 3.5 cents less than the average farm price for the country, and the period ending in 1880 just 1 cent lower than the farm price for the same period. An analysis of these Chicago quotations shows that price depends on quantity. Thus, in 1862 it was 23 cents; in 1865 it was 88 cents. In 1879, after several years of abundance, it was 29.8 cents, but in 1875, after a short crop, it was 66.3 cents. So, in 1890, after the largest crop grown and one of the largest per head, the price was 29.3 cents, while in 1882, after a very short crop, the figure was 62.5 cents.

We can have corn at 30 cents or at 60 cents per bushel, if we can regulate the supply. Now, it would not be advantageous to farmers, in the long run, to keep corn at 60 cents, but it would equalize general prices and advance the general prosperity to keep it in the neighborhood of 40, or about the average of the last twenty years. This can be done by the farmers themselves, but only by restricing the supply to the requirements of the home market or increasing the foreign demand.

It is not asserted here that there are no other causes operative in modifying prices, but they are limited and obscure compared with the relative quantity of the supply.

The following table gives the average farm price of corn in the seven States having an annual surplus from 1876 to 1889, exclusive:

States.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.
	Cts.	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*
Ohio	40	33	39	41	61	62	47	41	32	35	48	35	31	51
Indiana	34	27	34	40	60	48	41	34	29	32	45	31	27	47
Illinois	29	25	31	36	58	47	40	31	28	31	41	29	24	43
Iowa	25	16	24	26	44	38	32	23	24	30	35	24	19	41
Missouri	27	26	25	36	65	39	35	26	25	31	37	30	23	44
Kansas	21	19	27	29	58	37	26	22	24	27	37	26	18	51
Nebraska	18	16	21	25	39	33	24	18	19	20	30	22	17	48
United States	35.8	31.8	37.5	39.6	63.6	48.4	42.4	35.7	32.8	36.6	44.4	34.1	28.3	50.6

The price in 1889 was lower in all these States than in any other year of this record, excepting that in Indiana, in 1878, it was the same and in the same year in Iowa and Nebraska a lower price was reached. There was discouragement and depression as a result of these low prices. The reduction was attributed by unthinking people to all sorts of extraneous causes, financial and political, and the great crop was divided up theoretically into daily individual rations to show how small an allowance it really was. While grumbling over the unremunerative prices, the untoward meteorology of 1890 was silently and surely working a cure for low prices. A glance at that statement of prices is a wonderful revelation of sudden advance. The average of Ohio jumps from 31 to 51 cents; Indiana, from 27 to 47; Illinois, from 24 to 43; Iowa, from 19 to 41; Missouri, from 23 to 44; Kansas, from 18 to 51; Nebraska, from 17 to 48. Never before was the price so high in Nebraska since the State was self-supporting. In Iowa, Missouri, and Kansas, only in 1881 were prices higher, and in Ohio, Indiana, and Illinois only in 1881 and 1882. So radical a change is not desirable, because the production in large districts beyond the Missouri is not sufficient for consumption, and only the best farmers there have any corn for sale; yet it is a harsh but irresistibly forcible illustration of the truth that prices still depend on the relation of supply and demand.

WHEAT PRICES.

The farm price of wheat has exceeded a dollar per bushel only one year in the past decade, and that was in 1881, the year of low yield so well remembered by all our farmers. A sharp fall occurred in 1884, a year of large production in this country, in Europe, and in India. In six years, from 1884, low prices have prevailed except in 1888, in which the product dropped heavily. Relatively the December value of the present crop was higher than that of 1887, and 9.3 cents higher than that of 1884. The present quotations of wheat are nearly up to the highest records of the past six years. There is nothing very depressing in current wheat values. The gradual reduction of stocks of old wheat, visible and invisible, promises continuance of higher prices. Prospects of larger products, good yields in other countries, would tend to hold at present rates or reduce somewhat the quotations of the future. Thus is the wheat grower's profit dependent on the friendly alliance of rust, blight, and insect depredations in other fields.

The States this side of the Rocky Mountains which cut a figure in the commercial distribution of wheat are found in the following table of average farm prices on the 1st of December of each year. The time includes the period of crop failure in Western Europe from 1876 to 1879, inclusive, which is responsible for the heavy exportation and high prices of this period. The high price in 1881 was due to a crop "failure" in this country. This period was the same in which our wheat acreage was so greatly enlarged. Since 1884 prices have been comparatively uniform, not to say uniformly low. The causes controlling these prices are as plainly visible as the bright rays of the morning sun, and the local differences indicated in the table are as plainly visible. Even the low ebb of last year's averages for Kansas and Nebraska is explained by abundance of home supply, distance from market, lack of facilities for handling and sale of surplus, and comparative lack of high favor for milling purposes, which operates so generally in Dakota and Minnesota.

The following table affords opportunity for study of local prices and their changes:

Average farm price of wheat for the years 1877 *to* 1890.

States.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890
	Cts.	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*	*Cts.*
Ohio	124	86	120	102	129	95	99	75	91	74	75	97	76	91
Michigan	122	85	117	97	125	90	96	74	84	73	74	98	74	90
Indiana	113	81	117	99	127	90	95	67	86	70	72	94	71	88
Illinois	104	75	107	95	122	86	92	63	81	69	70	93	70	87
Wisconsin	93	67	104	100	119	90	88	60	76	68	64	96	70	83
Minnesota	91	51	94	87	106	82	80	50	70	61	59	92	71	81
Iowa	87	50	92	82	106	70	80	55	67	60	61	85	63	80
Missouri	100	67	101	89	119	85	88	62	77	63	62	88	64	83
Kansas	82	59	89	70	105	67	78	45	65	58	61	88	55	77
Nebraska	83	49	84	73	97	67	70	42	57	47	53	83	52	76
Dakota	......	......	......	......	....	80	72	46	63	52	52	91	60	70
United States	108.2	77.7	110.8	95.1	119.3	88.2	91	64.5	77.1	68.7	68.1	92.6	69.8	83.8

A record of Chicago Board of Trade prices on the 1st of January since 1860, which are herewith given, shows that the lowest price in thirty years was in 1862, when the quotation was 76.5 cents. The premium on gold made abnormal currency values for a dozen years and more, and caused a difference in price more apparent than real. The average of these January prices, by decades, is 128.6 cents per bushel in the first, 110.5 in the second, and 90.7 cents in the third. The difference in gold values is slight between these decade averages. Still there are annual fluctuations, caused by fluctuating supply of the world, in which our surplus exercises a large, if not controlling influence. For instance, since 1880 the range of quotations has been from 126.8 cents in 1882, to 75 cents in 1885. Only three years sufficed to make the change from the highest to the lowest. So the lowest 1st of January record in ten years was not in 1890, when the price was 78 cents, but five years ago. Last January's price was a little higher than that of 1885, but 22 cents lower than in 1889, and the only reason that dollar wheat was then marketed was the fact of a poor crop, a little better than that of 1881, which sent the January price (1882) to 126.8 cents.

If wheat growers should insist on growing 600,000,000 bushels, and at the same time demand a dollar per bushel, under existing conditions elsewhere, no exercise of power by the Government could

possibly guaranty such a market price, or prevent its reaching a lower depth than it has hitherto reached.

CHICAGO PRICES OF CEREALS.

The following table gives the Chicago prices of cereals from 1861 to 1890, inclusive, as reported by the Board of Trade on or about the 1st of January of each year.

[Prices given in cents per bushel.]

Years.	Corn.		Wheat.		Oats.		Rye.		Barley.	
1861	28 to	28½	82 to	83	17 to	17½	45½ to	46	38 to	43
1862		23	76	77		18		32		35
1863	42	42¾		115	43	45		60		85
1864	47½	48		126	66	66½		102½	121	122
1865		88		176	64¾	65½		112	125	135
1866	45	46	122½	131	24¼	26	49	55	......	......
1867	74¾	75½	193	200	41	42½	......	......	......	......
1868	86	86¼	193	198	55	56½	......	......	......	......
1869		56	114	115½	45½	47	114	119	162	168
1870	69	72	77¼	77¾	39½	40	......	......	......	......
1871	43½	44	109	111	39	39¾	75	76	70	78
1872	40½	40⅞	120½	121⅜	31⅞	32⅛	63¼	67¼	60½	63½
1873	30⅝	31	119½	125¾	24½	24¾	66	68	64½	65
1874	53¼	53½	117¼	118	38¼	38½	76½	78	138	145
1875	66	66½	90½	90¾	52¾	53	95	98	123	128
1876	43	45	95	96⅜	29⅞	30¼	66	67	78	80½
1877	43¾	44⅜	124¾	126½	33⅞	34⅝	72	72½	64	67½
1878	42⅜	43½	107⅞	109⅛	24¼	24⅞	56	56½	57½	58
1879	29½	30	81⅝	83	19½	19⅝	43	43½	95	97½
1880	39¾	40⅜	130	132½		35	80¾	80⅛	82	85
1881	36	37½	95⅜	98½	30⅛	31¼	85	88	112	115
1882	60⅞	63½	125¾	127⅝	43⅞	45	95½	96	105	108
1883	49⅝	54¼	93½	96	35	35¾	57	58		85
1884	54½	57¾	93⅜	95½	32½	33⅞	58½	59	61	62
1885	34¼	34⅞	72⅛	78¼	25¼	25½		[illegible]3		61
1886	36⅛	36¼	84⅛	85		28	58½	59	65	66
1887	36¼	37⅜	78	80⅛	26¼	26½		53	52	53
1888	48⅞	49¼	77	7[illegible]¾		31¾		62		83
1889	33⅝	33¾	99¼	101		25⅛		50	......	......
1890	29¼	29½	77¾	78⅛	20⅛	20½		44½	......	......

The following record of California prices of wheat (given for centals, but reduced to bushels of 60 pounds) was made by Albert Montpelier, manager of the Granger's Bank, San Francisco:

Years.	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.
	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.
1877-'78	136	134	139	140	138	142	134	122	117	119	115	101
1878-'79	100	102	104	103	102	102	101	101	99	97	98	99
1879-'80	101	101	105	118	122	122	117	115	116	102	95	92
1880-'81	90	87	80	87	91	87	82	79	80	82	83	83
1881-'82	82	92	100	101	103	99	99	98	98	97	100	101
1882-'83	102	101	99	99	100	101	108	114	116	106	105	98
1883-'84	95	101	102	101	109	110	105	97	95	92	91	87
1884-'85	83	79	72	75	75	76	78	77	77	84	86	84
1885-'86	85	83	85	89	84	83	81	77	78	81	79	77
1886-'87	75	78	80	81	83	89	94	90	94	103	107	119
1887-'88	113	.....	75	77	80	83	82	80	79	79	84	79
1888-'89	81	89	91	96	95	87	84	85	83	83	79	77
1889-'90	79	79	77	78	78	77	77	76	77	77	79	77

The very high prices of 1887, 36 cents higher in July than in July of 1878, followed a crop a fraction above 10 bushels per acre for the

whole country. It is seen that the averages for 1888–'89 were as high as those of the period 1886–'87 and 1887–'88 and higher than in 1885–'86.

The recent increase in prices.

Markets and items.	Unit of measure.	1889.				1890.				1891.	
		January 2.		July 1.		January 2.		July 1.		January 2.	
Portland, Me.:											
Corn	Bushel	$0.57 to	$0.59	$0.50		$0.50 to	$0.51	$0.48 to	$0.49	$0.69 to	$0.70
Oats	...do	.40	.42	.40 to	$0.42	.34	.35	.40	.41	.56	.57
Potatoes	...do	.50	.60	.65	.70	.70	.75	.75	.85	.90	1.00
Hay, loose	Ton	12.00	15.00	14.00	17.00	14.00	17.00	12.00	14.00	12.00	14.00
Butter, creamery	Pound	.28	.32	.23	.25	.23	.25	.21	.23	.25	.28
Cheese, sage	...do	.14¾	.15½	.14¼	.15½	.12½	.13½	.12	.13	.12½	.13½
Eggs	Dozen	.27	.30	.16	.18	.25	.26	.16	.17	.29	.30
Lard, keg	Pound	.09	.10	.07¼	.08	.06¾	.07½	.06½	.07½	.07	.10½
Wool, fleece-washed	...do	.25	.28	.25	.28	.25	.28	.28	.30	.25	.35
Boston, Mass.:											
Corn, No. 2 mixed	Bushel	.46		.46		.41	.41½	.44½			.64½
Oats, No. 2 white	...do	.35½	.36½	.35¼	.36¼	.32	.32¾	.37½			.55½
Rye	...do	.67		.60		.....	.....	.65		.78	.80
Barley, 2-rowed State	...do	.80		.....	.....	.55	.58	.72	.75	.85	.88
Potatoes, Holton Hebrons	...do	.58	.60	.....	.....	.70		.....	.....	1.05	1.08
Hay, fair to good	Ton	16.50	17.50	17.00	17.50	14.00	15.00	14.00	15.00	13.00	14.00
Butter, extra dairy	Pound	.26	.27	.18		.22	.23	.15	.16	.24	.25
Cheese, Vermont extra	...do	.11¾	.12	.08½	.08¾	.10¼	.10½	.07¾		.09¾	.10
Eggs, Eastern extra	Dozen	.23	.24	.17		.25		.16			.28
Lard, city rendered	Pound	.09	.09¼	.07½	.07⅝	.6¼	.07	.06½	.06¾	.06½	.06⅝
New York:											
Wheat, No. 2 winter	Bushel	1.02¼	1.04⅝	.87¾	.88½	.87	.87½	.95⅜	.96⅜	1.04¾	1.05⅛
Corn, No. 2 mixed	...do	.47¼	.48	.42¾		.40¼	.40⅜	.41¾	.42	.61⅞	
Oats, No. 2 mixed	...do	.30⅞	.31½	.28⅝	.28¾	.28⅝	.28¾		.34	.49⅜	.49½
Rye, State	...do	.60	.64	.52	.53	.56	.60	.56	.57½	.78	.80
Barley, 2-rowed, State	...do	.78	.80	.....	.....	.51	.53	.....	.....	.83	.85
Pork, prime mess	Barrel	14.25	14.50	13.25	13.50	10.00	10.50	13.25	13.75	11.50	12.00
Butter, State dairy	Pound	.27	.28	.17	.18	.21	.22	.15		.23	.25
Cheese, State factory	...do	.12		9	.09⅛	.10	.10½	.08¼	.08½		.09¾
Eggs	Dozen	.20	.21	.14	.14½	.23	.24	.15		.....	.....
Hay	100 lbs	.90	.95	.90		.80	.85	.85	.90	.55	.65
Tobacco, Connecticut leaf	Pound	.10	.20	.15	.25	.15	.25	.15	.25	.11	.23
Tobacco, Virginia wrapper	...do	.12½	.15	.12	.16	.12	.16	.12	.16	.10	.23
Philadelphia, Pa.:											
Wheat, winter	Bushel	.97½	.98	.95		.81	.81½	.89½	.90	1.04	
Corn, No. 2 mixed	...do	.42¾	.42⅝	.43¼	.43½	.36	.36½	.41⅛	.42	.60	
Oats, No. 2 white	...do	.34	.34½	.33½		.29½	.30	.35½		.50¼	
Hay, timothy	Ton	14.00	17.00	11.00	16.00	11.00	13.00	10.00	12.25	10.50	
Baltimore, Md.:											
Wheat, No. 2 red, winter	Bushel	.95		.85¾		.79¼		.89		.96	
Corn, mixed	...do	.42		.41½		.36⅜		.41¼		.57½	
Oats, No. 2 white	...do	.33		.34		.31		.35½		.50	
Rye, No. 2	...do	.58		.49	.50	.57		.55		.80	
Hay, timothy	Ton	16.00	17.00	15.00	15.50	12.50	13.50	11.00	12.50	9.50	11.00
Wool, tub-washed, fair to choice	Pound	.32	.35	.33	.38	.34	.36	.34	.35	.32	.35
Atlanta, Ga.:											
Wheat, winter	Bushel	1.12		.....	.....	.75		.....	.....	.....	.....
Corn, white	...do	.58		.56		.52	.54	.57			.75
Oats, No. 2 mixed	...do	.40		.38½		.32	.34	.40			.59
Potatoes	Barrel	2.25		3.00		1.50		2.00			3.75
Hay	Cwt	1.05		.95	1.05	.90	.95	.90			.90
Beef, dressed	Pound	.05		.05¾		.06	.06½	.06			.06
Cotton	...do	.09½		.10½		.09½	.09⅝	.11			.08½
Eggs	Dozen	.....	.....	.12	.14	.22		.12½			.26
New Orleans, La.:											
Corn, No. 2 white	Bushel	.46	.47	.48	.49	.39		.47			.61
Oats, No. 2	...do	.35		.33	.33½	.30		.37½			.54
Hay, prime	Ton	16.50	17.50	14.00	15.00	12.00	14.50	14.00	15.00	14.00	15.50
Pork	Barrel	14.25		13.00	13.25	10.37½		12.75			9.75

The recent increase in prices—Continued.

Markets and items.	Unit of measure.	1889.				1890.				1891.	
		January 2.		July 1.		January 2.		July 1.		January 2.	
Cincinnati, Ohio:											
Wheat, No. 2 red, winter	Bushel	$0.95 to	$0.97	$0.88 to	$0.90	$0.76 to	$0.78	$0.85 to	$0.87	$0.96 to	$0.97
Corn, No. 2 mixed	...do	.34½	.35	.38	.38½	.30	.31	.37½	.38	.52½	
Oats, No. 2 mixed	...do	.27½		.25	.25½	.23½	.24	......	......	.43½	.44
Rye, No. 2	...do	.56½	.57	.44	.46	.46	.48	.50		.73½	.74
Potatoes	...do	.30	.40	.25	.30	.30	.35	.40	.50	.95	1.00
Hay, timothy	Ton	13.50	14.00	11.50	12.00	10.00	11.00	9.00	10.00	9.00	9.50
Pork, mess	Barrel	13.50	13.62½	12.12½	12.25	9.50		13.00	13.75	10.00	10.12½
Butter, fancy creamery	Pound	.35		.18	.20	.29	.30	.18		.30	.31
Cheese, Ohio factory	...do	.11	.11½	.07	.08	.09	.09½	.07	.08	.09	.09½
Eggs	Dozen	......	......	.11	.11½	.15		.10		.20	
Chicago, Ill.:											
Wheat, No. 2 red, winter	Bushel	.99¼	1.01	.82½	.84	.77¾	.78½	.85⅜	.88	.88½	.89¾
Corn, No. 2	...do	.33⅝	.33¾	.35	.35¼	.29¼	.29½	.33⅞	.34⅛	.48¾	.49½
Oats, No. 2	...do	.25⅛		.22⅝	.22¾	.20⅛	.20½	.27⅞		.42	.42½
Rye, No. 2	...do	.50		.42½	.43	.44½		......	......	......	......
Hay, No. 1 timothy	Ton	11.00	11.50	10.00	11.00	9.00	10.50	10.00	11.50	9.00	9.75
Beef, extra mess	Barrel	6.00	6.25	6.25	6.50	5.75	6.00	6.00	6.25	5.50	5.75
Pork, mess	...do	12.85	12.87½	11.70	11.75	9.10	9.12½	11.25	12.00	10.20	10.25
Eggs	Dozen	......	......	.12		.16	.17	.10	.10½	.22	
Milwaukee, Wis.:											
Wheat, No. 2 spring	Bushel	.95		.78⅜		.72½		.83		.83¾	
Corn, No. 3	...do	.31		.35¼		.28	.28½	.35	.35¼	.47½	.48¼
Oats, No. 2 white	...do	.27½	.28	.27½		.22¼	.22½	.29½	.30	.42	.43
Barley, No. 2	...do	.67		.50½		.47		.48½		.66½	
Rye, No. 1	...do	.49¾	.50	.43½		.45		.48¼		.67	
Potatoes	...do	.30	.35	.25	.35	.30	.40	.40	.65	.75	1.00
Hay, timothy	Ton	9.00	11.00	10.00		7.00	9.00	8.00	9.00	8.00	8.50
Pork, mess	Barrel	12.80		11.65		9.75		11.00		10.25	
Beef, extra mess	...do	6.75		......	......	6.50		6.50		6.25	
Butter, creamery	Pound	.22	.27	.15	.16	.21	.23	.14	.14½	.23	.25
Cheese, Wisconsin	...do	.09½	.12	.07½	.08	.09½	.11	.07	.08	.09½	.10½
Wool, washed	...do	.28	.33	.26	.28	.25	.33	.25	.31	.25	.26
St. Louis, Mo.:											
Wheat, No. 2 red, winter	Bushel	.95¼	.95½	.84¼		.78		.85¼		.92¾	.93⅝
Corn, No. 2	...do	.30	.30⅛	.31		.25¼		.33½		.47	.48
Oats, No. 2	...do	.24½		.22¼		.19½		.28¾		.42⅝	
Rye, No. 2	...do	.47½	.48¼	.40		.42		.45		.64¼	.63
Potatoes, choice	...do	.40	.42	[illegible]		.40	.45	.80	.90	.95	1.10
Hay, timothy	Ton	13.25	16.00	12.00		12.00		14.50		12.00	13.00
Beef, family	Barrel	8.50	10.00	8.50	10.00	8.50	10.00	8.50	10.00	......	......
Pork, mess	...do	13.75	14.25	12.25		9.50		11.50		10.37½	10.50
Lard, prime steam	Pound	.07¼		.06¼		.05 35/100		.05½		.05½	.05⅗
Eggs	Dozen	......	......	.10		.14		.08		.18½	
Tobacco, Missouri burley	100 lbs	4.00	7.00	5.00	6.50	5.00	6.00	4.00	6.50	5.00	6.50
Wool, tub-washed, fair	...do	.35	.36	.34	.35	.32	.33	.32	.33	.30	.32
San Francisco, Cal.:											
Wheat, No. 1 white	Cental	1.42½		1.30		1.26¼		1.31¼		1.35	
Barley, No. 2 brewing	...do	.88¾		......	......	.92½		......	......	1.52½	1.55
Oats, No. 2	...do	1.06		.99¾		1.17½	1.20	1.53½	1.55	1.82½	1.85
Corn, No. 1 white	...do	1.07½		1.12½		1.05		1.00	1.05	1.32½	1.35
Rye, No. 1	...do	1.85		1.05		1.00		.92½		1.32½	1.35
Potatoes	...do	.45		.75		1.55	1.60	1.25		.90	1.15
Hay, No. 1 oats	Ton	12.50		10.00		9.00	11.00	9.00	12.00	13.00	14.50
Butter, good to choice	Pound	.27½		.15	.17	.17	.20	.13½	.14½	.32½	.36
Cheese	...do	.10	.14	.06	.07	.08	.12½	.06	.08	.11	.13
Eggs, choice	Dozen	......	......	.30		.35	42½	.20	.22½	.30	.32½
Wool, Oregon Valley	Pound	.20	.22½	.21½	.24	.19	.20	.18	.21	.20	.22

An examination of this table shows extraordinary advance in price, especially in corn and oats, since January of last year. In corn the increase amounts to about 66 per cent in Chicago, 70 in Milwaukee and Cincinnati, 88 in St. Louis, and 62 in New York. No. 2 in Chicago advanced from 29¼ and 29½ to 48¾ and 49½; and in New York from 40¼ and 40⅝ to 61¾. The Chicago price of oats more than doubled, advancing from 20½ to 42½. There was much less difference in the rates for wheat, the advance being from 78 to 89 in Chicago, and from 78 to 93 in St. Louis. These prices are proving an effective antidote for depression.

COTTON PRODUCTION AND TRADE OF THE WORLD.

The cotton plant can be grown in various sections of the world lying within the parallels of 35° of latitude north and south, and in this belt is contained the largest portion of the land surface of the globe. It is cultivated to a greater or less extent by almost every people inhabiting this portion of the earth's surface, though the districts between 20° and 35° north latitude seem now best adapted to its profitable culture. Within these lines lie the cotton districts of the United States, Northern Mexico, Egypt, Northern Africa, and of Asia, except the extreme southern portions of India and the Malay peninsula. South of the equator it is grown in Brazil, where practically almost the whole Empire may be said to be suitable for its culture; in Australia, though its cultivation has never been successfully carried on to any extent, and in Africa, where the extent of its growth and its consumption as yet are mere matters for conjecture and speculation. In fact, the area on which cotton of some kind may be produced is practically limited only by the requirements for the product. It is the fiber which is adapted for use under the widest conditions of climate and civilization, and it is the only one yet known which is and can be produced in such quantities and so cheaply that the permanent demand can not possibly exceed the supply.

PRODUCTION OF THE WORLD.

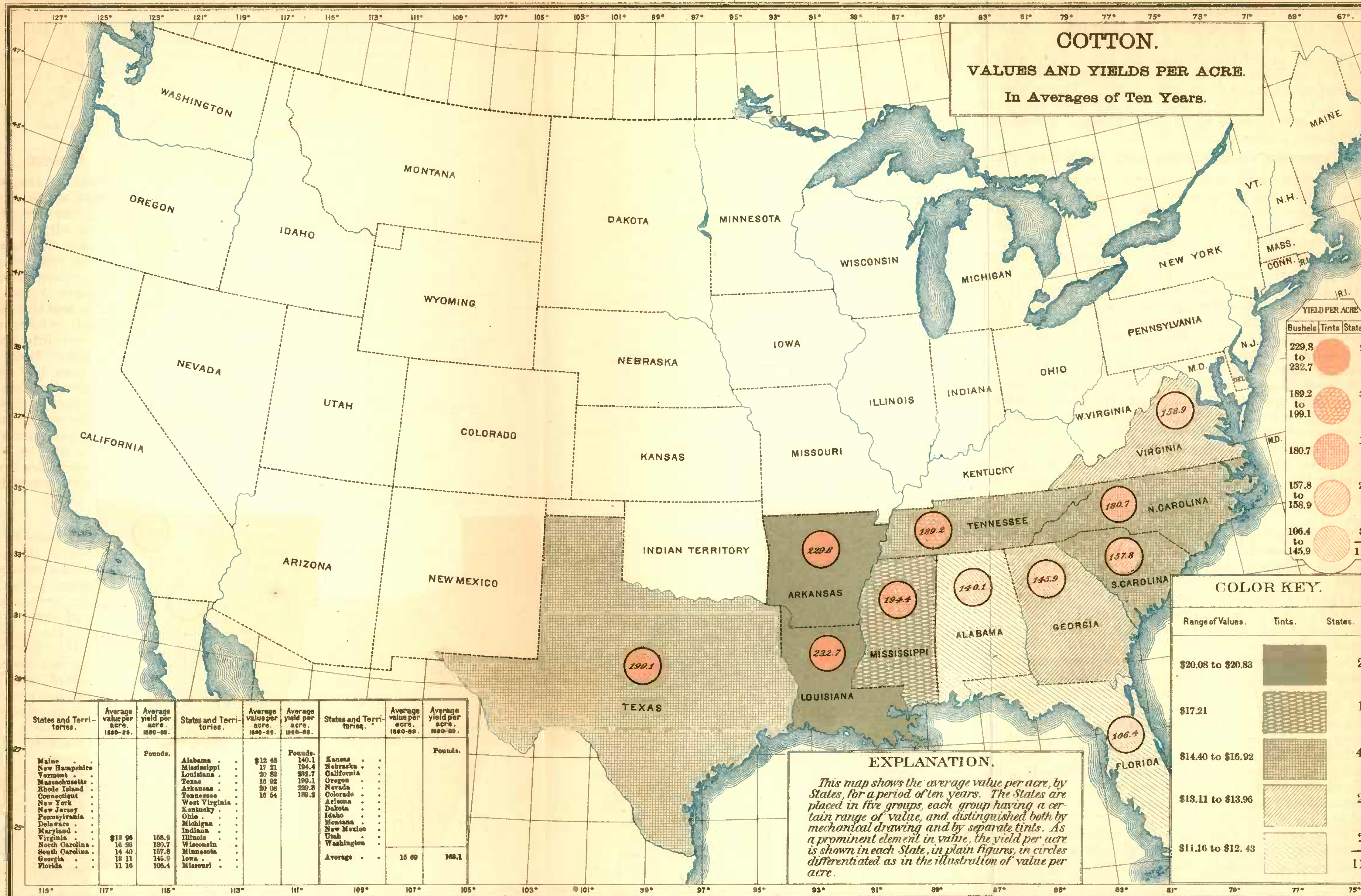
It is less than seventy years since the first attempt was made to keep an accurate record of the annual production of cotton in this country, and accurate statistics for other civilized countries where the staple is grown, are only available for a much more recent period. A large proportion of the fiber entering into civilized commerce, and not grown in the United States, is produced in countries of semicivilization, and of this product there is no accurate record. Its aggregate can only be approximated from the amount entering the channels ot trade, supplemented by the probable requirements for domestic consumption. To render still more complicated the task of compiling a statement of the world's aggregate production there are countries and districts where it is largely grown and for which absolutely nc data are available. The extent of its cultivation in China is a close secret, though the suitability of its soil and the character of the clothing of the population of the Empire make it certain that the production of the country is very considerable. Even in India, outside of the British districts, statements of production are only approximations based largely upon the amount coming into sight anc the known requirements of the natives for dress.

The interior of Africa is a vast unknown continent, but the exten of territory capable of growing cotton must be very great. Th population of this dark quarter of the globe is a matter of the meres

COTTON.

VALUES AND YIELDS PER ACRE.

In Averages of Ten Years.



Bushels	Tints	States
YIELD PER ACRE		
229.8 to 232.7		2
189.2 to 199.1		3
180.7		1
157.8 to 158.9		2
106.4 to 145.9		3
		11

States and Territories.	Average value per acre. 1880-89.	Average yield per acre. 1880-89.	States and Territories.	Average value per acre. 1880-89.	Average yield per acre. 1880-89.	States and Territories.	Average value per acre. 1880-89.	Average yield per acre. 1880-89.
		Pounds.			Pounds.			Pounds.
Maine			Alabama	$12 48	140.1	Kansas		
New Hampshire			Mississippi	17 21	194.4	Nebraska		
Vermont			Louisiana	20 83	232.7	California		
Massachusetts			Texas	16 92	199.1	Oregon		
Rhode Island			Arkansas	20 08	229.8	Nevada		
Connecticut			Tennessee	16 54	189.2	Colorado		
New York			West Virginia			Arizona		
New Jersey			Kentucky			Dakota		
Pennsylvania			Ohio			Idaho		
Delaware			Michigan			Montana		
Maryland			Indiana			New Mexico		
Virginia	$13 96	158.9	Illinois			Utah		
North Carolina	16 26	180.7	Wisconsin			Washington		
South Carolina	14 40	157.8	Minnesota					
Georgia	13 11	145.9	Iowa			Average	15 69	168.1
Florida	11 16	106.4	Missouri					

EXPLANATION.

This map shows the average value per acre, by States, for a period of ten years. The States are placed in five groups, each group having a certain range of value, and distinguished both by mechanical drawing and by separate tints. As a prominent element in value, the yield per acre is shown in each State, in plain figures, in circles differentiated as in the illustration of value per acre.

COLOR KEY.

Range of Values.	Tints.	States.
$20.08 to $20.83		2
$17.21		1
$14.40 to $16.92		4
$13.11 to $13.96		2
$11.16 to $12.43		2
		11

Geo. S. Harris & Sons Lith. Phila.

conjecture, and while the decrees of fashion demand but scanty clothing, it is known that in all sections of the vast territory yet visited cotton fabrics largely compose the native clothing. It is scanty, but in the aggregate must absorb a large annual production of the fiber. The greater part of the crop of the world is grown by colored labor, and our Southern States may yet find their competitor for the world's market in their own class of labor at work under the tropical skies of its native home.

When the difficulties in the way of procuring a reliable estimate of the world's product, in this present age of progress and statistical information, are considered, it will be seen how little reliable are statements of that product fifty and one hundred years ago. The increase in production since the introduction of the saw gin has been enormous, but has been largely confined to the new world. The primitive methods of a century ago are still mainly followed in Asia and Africa, and if the aggregate product of those continents has increased at all, it has been probably only in proportion to population. It is a question whether in the aggregate the last century has not witnessed a decline, on account of the introduction into these lands of cheap manufactured goods. The competition between the new and the old systems of production, between improved implements and machinery and hand power, can have but one result, though the element of cheap labor may support the primitive methods for a time.

Among the earliest and most pretentious estimates of the world's production are those put forth in a letter from Levi Woodbury, Secretary of the Treasury, to James K. Polk, Speaker of the House of Representatives, dated February 29, 1836, and in response to a resolution of the House. The report accompanying gives evidence of a very careful and thorough study of the entire subject. The estimates are evidently based upon the most reliable data to be obtained, and are doubtless as nearly correct as any statement of the product of the world at the dates given could be made.

These estimates, in pounds, are as follows:

	1791.	1801.	1811.	1821.	1831.	1834.
United States	2,000,000	48,000,000	80,000,000	180,000,000	385,000,000	460,000,000
Brazil	22,000,000	36,000,000	35,000,000	32,000,000	38,000,000	30,000,000
West Indies	12,000,000	10,000,000	12,000,000	10,000,000	9,000,000	8,000,000
Egypt	....	....	83,333	6,000,000	18,000,000	25,000,000
Rest of Africa	46,000,000	45,000,000	44,000,000	40,000,000	36,000,000	34,000,000
India	130,000,000	160,000,000	170,000,000	175,000,000	180,000,000	185,000,000
Rest of Asia	190,000,000	160,000,000	146,000,000	135,000,000	115,000,000	110,000,000
Mexico and South America, except Brazil	68,000,000	56,000,000	57,000,000	44,000,000	35,000,000	35,000,000
Elsewhere	....	15,000,000	11,000,000	8,000,000	4,000,000	13,000,000
The world	490,000,000	520,000,000	555,083,333	630,000,000	820,000,000	900,000,000

NOTE.—The error in the footings of the first two columns is made in the original document.

The first of these estimates is for a year prior to the invention of the gin, and illustrates admirably the distribution of the industry at the close of the first period in the history of cotton growing. The year for which the estimate is made, 1791, is almost the last year in which cotton was raised and laboriously cleaned by hand labor for spinning by the primitive methods in vogue before steam power was successfully applied. At that date the United States was practically unconsidered in cotton production, its crop being only about 10 per

cent of that of Brazil, and ranking lowest of all countries in which it was grown. During the succeeding decade the invention of the gin and the revolution of methods which marked the beginning of the present era of the industry, stimulated the culture of the plant in this country, making it one of our agricultural staples. During the ten years the production of this country increased from 2,000,000 to 48,000,000 pounds, making the United States rank as fourth in the countries of production.

Between 1811 and 1821 this country attained its present position of the principal cotton-growing country of the world, and by 1834 it grew more than one half of the aggregate product of the world.

Beginning with 1827, there is a record of the commercial movement of the crop each year in the United States which practically covers the entire production. This actual record, with the estimates of Secretary Woodbury, makes it possible to present the following statement showing our production in periods ten years apart since 1791:

Year.	Pounds.	Year.	Pounds.
1791	2,000,000	1851	1,421,413,340
1801	48,000,000	1860	1,934,545,603
1811	80,000,000	1871	1,384,084,494
1821	180,000,000	1881	2,588,236,636
1831	444,364,650	1889	3,622,827,694
1841	759,903,750		

In preparing a statement of the aggregate production of the world at the present time, except in the case of the United States, only limited data are obtainable showing the actual product of any country, the estimates being necessarily based upon the known facts of exportation, population, and assumed consumption per head of each. Mr. Thomas Ellison, of Liverpool, after a most careful and painstaking investigation, makes a statement of the world's production at about the date of 1884, which as a whole can hardly be improved upon at present.

This statement is as follows, in bales of 400 pounds:

Country.	Bales.	Per cent.
United States of America	7,035,000	55.95
South America, West Indies, etc	300,000	2.38
East Indies	2,450,000	19.48
China	1,425,000	11.33
Japan	132,000	1.05
Turkey and Persia	120,000	0.95
Asiatic Russia	100,000	0.80
E ypt	625,000	4.97
Africa (except Egypt)	375,000	2.99
Italy and Greece	10,000	0.08
Australia, Fiji, etc	2,000	0.02
Total for the world	12,574,000	100.00

Since the date of this estimate the crop of the United States has materially enlarged, and instead of 2,814,000,000 pounds, as credited above, our production for 1889 amounted to 3,622,827,694 pounds.

The United States now consumes in its cotton manufactures between 30 and 33⅓ per cent of its annual production of the fiber, and the proportion is slowly but steadily increasing. Prior to 1840 more than three fourths of our production was consumed in foreign mills,

but our manufacturing interests have increased by a little more rapid ratio than our production. The following table presents in condensed form the average annual production and exportation, by decades, from 1841 to 1889:

Period.	Production.	Exportation.	Per cent exported.
	Pounds.	*Pounds.*	
1841-'50	1,013,706,315	739,182,698	72.9
1851-'60	1,656,2[illegible]7,661	1,118,106,790	67.5
1865-'70	1,297,745,903	860,437,420	66.3
1871-'80	2,183,174,113	1,493,829,284	68.4
1881-'89	3,144,427,868	2,125,612,794	67.6

With the exception of the period from 1871 to 1880 the proportion exported during each succeeding decade has declined. This break in the decline is due to the fact that production under the stimulus of free labor temporarily outran the increased capacity of our mills, but during the nine years since the demand has again adjusted itself to the enlarged supply, and the proportion of the crop seeking foreign markets again continues to grow smaller.

An interesting comparison of the average consumption of domestic mills in each section of the country since the war, in periods of six years, is presented. The figures represent actual consumption in bales of 400 pounds each:

Periods.	North.	South.	Total.
	Bales.	*Bales.*	*Bales.*
1866-'67 to 1871-'72	939,000	94,000	1,033,000
1872-'73 to 1877-'78	1,324,000	157,000	1,481,000
1878-'79 to 1883-'84	1,845,000	272,000	2,117,000
1884-'85 to 1889-'90	1,955,333	470,667	2,426,000

The figures of the last period are eloquent of the progress of the "New South." That section shows an increased mill consumption of more than 77 per cent over the preceding period, while the mills of the North during the same period increased their capacity only 6 per cent.

TRADE OF THE WORLD.

Cotton manufacture is carried on, to some extent, at least, in every country where the fiber is grown, though outside of Europe and the United States it is generally crude and by the most primitive methods. These countries weave the greater part of the cloth consumed in the world, and the fiber, in its raw and manufactured state, forms one of the most important items of their commerce.

The United Kingdom, by reason of its peculiar position and advantages, with its commercial supremacy, is the leading manufacturing nation. Her limited area, teeming population, and insular location make her naturally a manufacturing country, and this branch of industry was early developed and its improvements jealously guarded. Until within a year or two that country consumed more raw cotton in its domestic manufactures than the whole continent of Europe, but the continental countries are rapidly increasing the capacity of their mills and now demand the larger supply. The an-

nual average trade of Europe in raw cotton for a period of ten years is thus presented:

Countries.	Period.	Imports.	Exports.	Net imports.
		Pounds.	*Pounds.*	*Pounds.*
Austria-Hungary	1877-'86	176,435,968	18,200,592	158,175,376
Belgium	1877-'86	48,522,985	....	48,522,985
Denmark	1877-'86	961,640	911,033	50,607
France	1877-'86	300,153,424	80,645,370	219,508,054
Germany	1877-'86	370,518,480	59,776,384	310,742,096
Great Britain and Ireland	1877-'86	1,588,122,771	210,522,962	1,377,599,809
Italy	1877-'86	116,150,674	32,129,620	84,021,054
Netherlands	1877-'86	89,968,976	64,393,059	25,575,917
Norway	1877-'86	4,849,459	....	4,849,459
Portugal	1877-'86	7,690,968	....	7,690,968
Russia in Europe	1877-'86	229,451,573	....	229,451,573
Spain	1877-'86	97,988,297	....	97,988,297
Sweden	1877-'85	21,239,973	....	21,239,973
Switzerland	1877-'86	50,373,236	....	50,373,236
Total	....	3,102,428,424	466,639,020	2,635,789,404

The receipts of Great Britain and Ireland were more than those of all other countries. Germany, Russia, France, and Spain follow in order. This country is only exceeded in cotton manufacture by the United Kingdom, and should, ere many decades pass, attain the first rank.

According to the reliable records of Ellison & Co., of Liverpool, the United Kingdom now consumes about 37 per cent of the cotton of the world which enters the channels of civilized commerce, the rest of Europe 38 per cent, and the United States 25 per cent. Some fifty years ago, or during the period from 1841 to 1845, the average proportions were materially different. Then the United Kingdom used 55 per cent of the supply, the continent 30 per cent, and the United States only 15 per cent. This cotton is supplied by America, Brazil, East and West Indies, Egypt, etc., this country now furnishing 77 per cent. of the whole against 86 per cent fifty years ago. The cause of this slight decline in the proportion has been the heavy increase in the shipments from India, a trade stimulated to the greatest possible extent by English interests.

The following tables present in very condensed form the average annual consumption and supply in different five-year periods since 1841:

CONSUMPTION.

Periods.	Great Britain.	Continent.	United States.
	Pounds.	*Pounds.*	*Pounds.*
1841-'45	521,300,000	267,200,000	152,500,000
1851-'55	750,100,000	451,400,000	281,400,000
1861-'65	628,600,000	455,400,000	181,200,000
1871-'75	1,228,600,000	856,600,000	524,700,000
1881-'85	1,441,100,000	1,314,900,000	856,700,000
1886-'89	1,508,700,000	1,510,100,000	994,400,000

SUPPLY.

Periods.	America.	Brazil.	West Indies.	East Indies.	Egypt, etc.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
1841-'45	816,300,000	18,900,000	9,400,000	72,600,000	23,000,000
1851-'55	1,254,790,000	27,100,000	6,800,000	134,800,000	60,000,000
1861-'65	531,790,000	36,200,000	14,600,000	491,800,000	191,400,000
1871-'75	1,682,300,000	108,800,000	42,300,000	538,500,000	238,000,000
1881-'85	2,717,200,000	54,100,000	11,600,000	540,300,000	292,500,000
1886-'89	3,095,400,000	55,500,000	13,300,000	552,400,000	296,600,000

The export trade of countries which lack even and systematic development of all resources and industries is largely made up of raw agricultural products. The foreign trade of the United States is made up to the extent of some 73 per cent of farm products, and raw cotton constitutes about one third of the aggregate value, but the proportion of cotton and of all agricultural products is declining. As our population becomes denser, and our industries more diversified, we shall send abroad a smaller proportion of fiber and more manufactured goods, retaining for our own people both the profit in growing and spinning. At present, with the steady development of our manufactures which has taken place, we purchase cotton goods abroad, buying in 1890 nearly $30,000,000 worth, while we exported only $10,000,000.

This country possesses natural advantages which should make it the leading cotton-manufacturing as it is cotton-growing country of the world. The raw product produced at home in unlimited quantities is available without the expense of long distance transportation, while the inventive and progressive genius of our people insure the best machinery and methods. Our planters will continue to supply the demand from the Old World, but it will be a secondary object, the demand for domestic consumption being the first and more profitable. Cotton goods of American manufacture should be found in every market of the world, and especially should we monopolize this trade in our sister Republics of North and South America.

STATISTICAL GRAPHICS.

An Album of Agricultural Statistics has been issued during the past year to farmers' institutes, agricultural colleges, libraries, schools, boards of agriculture, and other organizations or individuals. The edition was limited to 10,000, and was therefore distributed with reference to use and practical utility. It is now nearly exhausted.

It consisted of sixteen maps of the United States, each representing a distinct topic, as follows:

I. Percentage of unoccupied and of farm lands, comprising the superficial area of each State.
II. Percentage of each grand division of farm area in each State.
III. Acreage in corn, per 1,000 acres of superficial area, in each State.
IV. Acreage in wheat, per 1,000 acres of superficial area, in each State.
V. Acreage in oats, per 1,000 acres of superficial area, in each State.
VI. Yield of corn per acre in each State.
VII. Yield of wheat per acre in each State.
VIII. Yield of oats per acre in each State.
IX. Average value of horses in each State.
X. Average value of cattle (exclusive of milch cows) in each State.
XI. Average value of milch cows in each State.
XII. Average value of sheep in each State.
XIII. Average value of swine in each State.
XIV. Rural population of the United States as a percentage of the total population by States.
XV. Average value of lands in the United States.
XVI. Farm tenures in the United States.

These maps are mainly based on results of past investigation conducted by the Statistician. The "distribution of cereals" is confined to the leading crops, which include all but 3 per cent of cereal

production. The rate of yield of corn, wheat, and oats, based on an average of ten crops, is also illustrated in three of this series, showing more effectively than by any other method the results of climatic adaptation, differing soils, and methods of culture. Another series of subjects treated is that of the average values of farm stock in different sections of the country, suggestive of differences in breed, degree of improvement, and effect of distance from market.

The following table presents the distribution of corn, wheat, and oats, by States, on the basis of the crops of 1888, showing the number of acres of each for every thousand acres of land surface of each State:

States.	Acres to each 1,000.			States.	Acres to each 1,000.		
	Corn.	Wheat.	Oats.		Corn.	Wheat.	Oats.
Alabama	75	13	13	Montana		1	1
Arizona		1		Nebraska	84	32	21
Arkansas	63	7	8	Nevada		1	1
California	2	24	1	New Hampshire	6	2	6
Colorado	1	2	1	New Jersey	73	30	29
Connecticut	18	1	13	New Mexico	1	1	1
Dakota	8	41	13	New York	23	22	46
Delaware	176	76	17	North Carolina	86	23	21
Florida	13		2	Ohio	110	102	41
Georgia	77	10	16	Oregon	1	15	3
Idaho		1	1	Pennsylvania	49	48	46
Illinois	217	68	107	Rhode Island	18		9
Indiana	157	121	47	South Carolina	82	10	21
Iowa	219	70	72	Tennessee	136	45	25
Kansas	113	20	32	Texas	29	3	4
Kentucky	123	40	19	Utah	1	2	1
Louisiana	35		1	Vermont	11	4	19
Maine	2	2	5	Virginia	83	24	26
Maryland	117	88	19	Washington	1	11	2
Massachusetts	12		5	West Virginia	43	19	9
Michigan	26	45	22	Wisconsin	31	35	42
Minnesota	14	61	30	Wyoming			1
Mississippi	65	3	12				
Missouri	149	35	31	Average	41	20	15

Another series of five maps illustrates the value of farm animals, horses, milch cows, other cattle, sheep, and swine. The averages are not those of a single year, but of the current estimates of ten consecutive years, eliminating the irregularities of annual fluctuation, and representing more fairly the local differences in values. The apparently extraordinary range of prices will attract attention, but will not excite a suspicion of inaccuracy in the minds of those acquainted with the facts. The largest factor in difference in value is breed; care and feed are also important causes of difference in price, and the distance from market is another consideration affecting value.

The first group in value of horses covers a small territory—the four States, New Jersey, Rhode Island, Massachusetts, and Delaware—and presents a range of prices from $96.21 to $87.06. The second group has a range from $85.96 to $75.22, comprising eleven political divisions, including New York and Pennsylvania in the Middle States, South Carolina and Georgia in the cotton States, and Minnesota and Dakota in the Northwest. The first named are in a populous section, demanding fine stock; the next mentioned are amply able to produce a surplus, while depending on Tennessee and Kentucky and other States for a large proportion of their domestic deficiency; and the

last are in an agricultural region of so rapid settlement as to render present importation an urgent necessity. The lower groups are found in agricultural districts where horses are raised for market as well as for use on the farm. In these, the culling process, for supplying the requirements of the principal markets, is continually reducing the value of the remainder, the young and less desirable of the mature stock. In Texas the lowest average appears because of the large number raised and the proportion of small animals of "Spanish" or Mexican origin. There are herds of horses in the Territories with a large infusion of good blood, which command somewhat higher prices.

The extremes are great in values of cattle. The lowest group represents Texan cattle, which came from Mexico originally, and from Spain more remotely—the long-horn tribes, hardy from survival of the strongest, and unimproved through generations of neglect. Until within fifteen years they were the export cattle of the United States, going to Cuba and adjacent islands. They go there still, and five nearly represent the value of one fat short-horn sent to England. In the more distant Western States, the grazing region, the average value is lower than in the States farther east which buy two-year-olds to feed and finish for the market. There are various considerations of breed, feed, and distance from market which cause differences in average values.

The value of milch cows is indicated on a separate map. Of course the groups above the average represent the dairy districts. In some of the Territories, however, values are high because of scarcity and demand for milk and butter in mining camps, as the females of large grazing herds are not reckoned as milch cows.

The value of sheep ranges from \$3.70 to \$1.34, depending on breed and grade, quality and quantity of wool, value for meat production, and distance from market. Every district has its peculiarities in sheep husbandry, including pedigree-stock growing, mutton producing, raising early lambs, and exclusive wool growing. Three fourths of all are Merino breeds and their grades; the English breeds are numerous in some sections; and grade Mexicans are common in the Southwest.

The value of swine has an extreme range, according to average age of slaughtering, which affects the average of weight, as do also the amount and kind of feed and length of feeding season. Where swine are kept for home use mainly, and the market for a possible surplus is precarious, average prices are very low, and the stock is usually slaughtered at an early age, as pigs of small average weight. In the pork-packing regions, on the contrary, feeding is liberal and weights are heavy, while the demand is sure and the prices generally remunerative.

The following table gives the average value per head, by States, for a period of ten years:

States.	Value per head.					States.	Value per head.				
	Horses.	Cows.	Other cattle.	Sheep.	Swine.		Horses.	Cows.	Other cattle.	Sheep.	Swine.
Alabama	$67.85	$15.14	$9.67	$1.48	$3.29	Montana	$54.89	$35.65	$23.55	$2.38	$7.98
Arizona	52.82	30.12	19.31	1.84	5.70	Nebraska	72.92	28.51	24.20	2.24	5.96
Arkansas	54.09	17.29	11.29	1.55	3.00	Nevada	55.75	37.21	22.46	1.87	6.69
California	56.14	32.49	22.90	1.77	5.15	N. Hampshire	72.41	29.45	30.46	2.81	10.81
Colorado	59.57	39.12	24.36	1.94	8.06	New Jersey	96.21	36.39	32.57	4.00	9.67
Connecticut	81.23	32.26	31.83	3.47	9.98	New Mexico	38.08	27.61	17.78	1.52	7.26
Dakota	76.49	27.77	23.64	2.52	5.84	New York	85.96	30.97	31.48	3.49	8.32
Delaware	87.06	29.87	26.87	3.28	7.12	North Carolina	69.93	16.20	10.03	1.34	3.58
Florida	75.22	13.47	8.27	1.80	2.40	Ohio	71.52	30.77	26.66	2.73	5.79
Georgia	75.98	16.53	9.92	1.49	3.32	Oregon	54.54	25.13	21.63	1.65	3.63
Idaho	54.74	34.50	22.58	2.25	7.43	Pennsylvania	84.41	29.90	27.23	3.12	8.16
Illinois	67.11	30.03	24.78	2.56	5.85	Rhode Island	94.30	33.70	32.82	3.70	10.50
Indiana	67.12	28.67	23.28	2.50	5.57	South Carolina	85.34	17.90	10.93	1.71	3.74
Iowa	68.07	27.33	22.81	2.55	6.02	Tennessee	60.43	20.04	13.48	1.64	3.74
Kansas	63.82	27.36	22.94	2.04	5.98	Texas	32.17	18.36	12.20	1.97	3.16
Kentucky	61.26	27.35	22.56	2.52	4.10	Utah	44.38	30.37	20.67	2.09	8.66
Louisiana	55.86	17.97	11.50	1.67	3.63	Vermont	72.95	27.25	26.97	3.46	8.67
Maine	76.39	28.29	27.22	2.88	9.08	Virginia	66.04	21.15	18.08	2.46	4.11
Maryland	77.03	29.97	23.65	3.28	6.35	Washington	64.65	33.31	24.90	2.22	5.63
Massachusetts	93.06	34.95	34.76	3.29	12.41	West Virginia	59.97	25.86	21.10	2.32	4.22
Michigan	80.99	30.80	25.76	2.75	6.20	Wisconsin	72.18	26.65	22.64	2.28	6.19
Minnesota	75.82	25.95	21.96	2.42	5.56	Wyoming	47.49	33.50	23.46	2.23	6.86
Mississippi	69.33	15.40	9.66	1.53	3.18						
Missouri	53.56	23.08	19.32	1.85	3.99	Average	66.11	26.53	19.87	2.21	4.97

ALBUM OF AGRICULTURAL GRAPHICS.

Another publication is in preparation and nearly ready for distribution, entitled *Album of Agricultural Graphics*. This is limited to the illustration of the values per acre of the ten crops which have been for years reported in the statistical investigation of the Department, as to area grown, yield, and value. These are the only crops for which there are data extant for a similar showing of yield per acre, and the information is therefore as complete and accurate as it can be made.

The graphic method adopted includes the main feature of the illustrations of distribution of crops and prices of farm animals in the Album of Agricultural Statistics. The differences in yield per acre by States are best shown by this method. They are indicated both by color and form, in five groups, distinguished by separate tints or degrees of density in color, and also by distinguishing differences in mechanical drawing. As there are two elements in value per acre, viz., the yield per acre and the value per unit of measurement, it was deemed very desirable to show the differences in yield, which is done in a manner that does not confuse in the least the two ideas, one of which is an important factor in producing the main result, viz., the value per acre. The average yield of each State is shown in plain figures in a circle of color different from the ground tint.

The average value per acre for these ten crops, each of which is represented by a separate map, is as follows:

States and Territories.	Average value per acre.									
	Corn.	Wheat.	Oats.	Rye.	Barley.	Buckwheat.	Potatoes.	Tobacco.	Cotton.	Hay.
Maine	$24.25	$17.42	$12.42	$12.26	$16.02	$10.14	$51.48			$11.31
New Hampshire	24.32	18.24	14.68	9.98	16.34	10.90	46.64			11.08
Vermont	23.18	19.75	13.87	11.85	18.05	10.88	47.06			11.08
Massachusetts	22.94	20.74	14.44	12.46	18.77	10.01	61.97	$204.28		18.82
Rhode Island	22.98		13.52	10.49	19.13	8.25	62.55			16.19
Connecticut	20.94	19.14	12.82	10.89	16.43	8.49	53.60	196.58		15.91
New York	18.39	15.03	11.12	8.51	16.91	8.22	37.79	159.56		13.67
New Jersey	17.83	13.58	10.57	7.75	12.56	8.34	47.26			16.79
Pennsylvania	17.16	12.66	10.51	7.34	14.74	8.47	37.59	143.22		14.00
Delaware	9.05	11.67	7.82	5.50		9.45	37.77			14.60
Maryland	11.88	12.09	7.29	7.13	20.47	8.84	37.68	44.24		14.47
Virginia	8.46	8.05	4.73	4.71	12.01	7.04	34.29	44.85	$13.96	13.64
North Carolina	7.15	6.42	4.56	4.82	9.65	6.10	38.33	51.21	16.26	13.45
South Carolina	6.19	6.73	6.18	5.09	14.88		46.11		14.40	15.71
Georgia	6.81	7.01	5.85	6.07	13.57		53.10		13.11	17.31
Florida	7.22		7.04				65.65		11.16	16.37
Alabama	7.69	6.60	6.36	6.28	11.38		56.02		12.43	16.54
Mississippi	8.47	6.35	6.40	7.29			53.01		17.21	16.16
Louisiana	9.54		7.07	11.19			54.03		20.83	14.50
Texas	9.52	9.25	9.98	8.51	10.79		58.21		16.92	12.20
Arkansas	10.07	7.23	7.68	6.57			47.14	50.22	20.08	13.90
Tennessee	8.92	5.95	5.20	4.67	9.27	5.66	30.49	48.30	16.54	14.14
West Virginia	11.80	9.63	6.47	6.09	12.98	6.66	34.90	56.29		10.41
Kentucky	9.97	8.23	6.36	6.23	14.15	6.88	30.90	58.63		12.70
Ohio	13.16	12.42	9.73	7.61	15.00	8.24	33.54	66.28		12.71
Michigan	13.16	13.40	10.44	7.69	15.96	8.75	32.02	64.24		13.22
Indiana	10.84	11.36	7.88	6.97	14.96	7.72	31.00	49.43		11.35
Illinois	9.38	11.32	8.95	8.86	12.88	7.65	35.24	48.18		10.26
Wisconsin	11.04	10.03	8.68	7.86	12.67	6.75	35.96	101.45		9.21
Minnesota	10.86	9.31	8.63	7.20	10.93	6.82	35.43			6.76
Iowa	8.63	7.56	7.34	6.42	10.34	7.60	32.51			6.39
Missouri	8.94	9.23	6.96	6.66	12.04	7.81	32.37	63.27		9.38
Kansas	7.90	9.41	6.64	6.12	7.90	8.72	40.07			5.55
Nebraska	7.58	6.87	5.78	5.51	7.59	7.25	30.68			4.82
California	18.99	10.35	13.74	8.34	12.77	15.69	56.61			16.02
Oregon	16.85	12.02	11.48	11.88	14.25	10.23	47.75			14.45
Nevada	17.60	15.96	18.15		18.29		76.25			12.95
Colorado	17.77	16.22	14.97	12.78	17.43		53.12			15.76
Arizona	16.73	12.73			14.03		50.65			13.71
Dakota	8.67	7.52	7.29	7.21	9.02	6.80	35.17			5.10
Idaho	18.28	14.17	15.09	8.41	18.06		58.62			11.26
Montana	20.12	14.48	15.24		18.03		73.03			12.58
New Mexico	15.04	12.93	10.78		14.98		61.27			13.52
Utah	13.54	12.71	11.29	6.85	12.60		37,89			8.35
Washington	17.50	12.16	15.08	11.17	16.54		54.91			13.10
Wyoming		14.87	13.78				58.91			11.41
Average	9.47	9.95	8.16	8.27	12.76	8.24	38.34	61.51	15.69	11.08

The highest value per acre of corn is $24.32, in New Hampshire, and the lowest $6.19, in South Carolina. In the great corn belt the average in Illinois was $9.38 and in Iowa $8.63. In the Missouri Valley the average is low by reason of great abundance and cost of transportation to market; in the South, because of lower rate of yield, while prices are medium or high. Though corn grows everywhere except at the higher elevations, with a wide range of local variation in different climates and soils, its largest rate of production is in the lower levels of the valleys of the Ohio and the Missouri. It is evident that climate as well as soil is a factor in this superior rate of yield.

The New England States and Colorado occupy the first group in value per acre of wheat, which ranges from $16.22 to $20.74. The second, from $15.96 to $13.40, includes Nevada, New York, Wyoming, Montana, Idaho, and New Jersey. The lowest group has

a range from \$6.87 to \$5.95. The seaboard region has the advantage of fertilization and high prices, though the areas cultivated are small.

The range of value per acre of oats is from \$18.15 in Colorado to \$4.56 in North Carolina. The yield per acre is 36 bushels to 9.5 bushels. Washington, Illinois, Minnesota, Vermont, Montana, Michigan, Iowa, New Hampshire, Colorado, Idaho, Ohio, and Wisconsin comprise the first group. All but three of these are on the Northern border. Oats deteriorate rapidly in quality and weight in the lower latitudes. In the South the crop can only be grown in winter.

Rye is a crop for poor soils and is not much grown in this country. The first group has a range of value from \$12.78 to \$11.17, the lowest from \$5.51 to \$4.67. The average yield in the South is lower by reason of the fact that it is grown more for winter pasture than for seed.

Barley has a higher value per acre than any other cereal, the first group having a range of \$20.47 to \$17.43 per acre. The lowest has a value from \$9.65 to \$7.59 per acre. The highest value per acre is in Maryland, where the yield averages 25.5 bushels under fertilization and generally good cultivation. The highest average yield is 29.1 bushels, in Washington. Still a large quantity is annually imported on account of the proximity of Canada to the great beer-manufacturing centers and the high malting quality of the Canadian product.

Buckwheat is by no means a general crop, the larger portion being grown in New York and Pennsylvania. The largest average value per acre is \$15.69, in California.

The average value per acre of potatoes is \$38.34 and the average yield 76.2 bushels. Like oats, the potato is adapted to cool climates of the higher latitudes. The range of yield is from 117 to 55 bushels and the average value per acre from \$76.25 to \$30.49.

The value of tobacco per acre is relatively high, with a very wide range, from \$204.28 to \$44.24 per acre. The highest yields and prices per pound are for seed-leaf tobacco, used exclusively for cigars, and grown solely in the Northern States, and mainly in a few counties on the Connecticut River, three in New York, three in Pennsylvania, and in limited districts in Wisconsin and Ohio.

The farm value of cotton ran from \$20.83 in Louisiana to \$11.16 in Florida. The yield per acre is highest in Louisiana, averaging 232.7 pounds of lint, and lowest in Florida, averaging 106.4 pounds, a part of which is sea-island cotton, which has a high relative value. Arkansas, Mississippi, Tennessee, and Texas follow Louisiana in the order of value, while the order in yield is Louisiana, Arkansas, Texas, Mississippi, and Tennessee.

The yield per acre is an important element in value per acre, but not the only one. The price per pound or bushel also differs, owing to distance from market and local scarcity or abundance. The tendency of railroad extension is toward equalization of prices, yet the difference in State averages of price shows how great differentiation in price still exists. It naturally happens that where prices are low yields are also low from lack of inducement to high culture, intensifying the disparity in values per acre. A study of these differences may surprise the casual reader and may prove fruitful of practical suggestions if made with care and thoughtfulness.

The average yield per acre of each State for ten years has been as follows:

States and Territories.	Average yield per acre.									
	Corn.	Wheat.	Oats.	Rye.	Barley.	Buckwheat.	Potatoes.	Tobacco.	Cotton.	Hay.
	Bush.	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Bush.*	*Lbs.*	*Lbs.*	*Tons.*
Maine	32.2	13.6	28.3	13.0	21.6	18.1	94.5			.97
New Hampshire	32.7	14.4	32.3	11.0	21.8	17.4	89.3			.93
Vermont	32.5	16.9	33.1	14.5	24.7	18.2	97.7			1.05
Massachusetts	31.6	16.3	29.9	14.3	23.2	14.2	95.5	1485.4		1.09
Rhode Island	30.2		27.9	12.1	23.9	10.4	91.8			.96
Connecticut	30.1	16.6	28.1	13.5	21.5	12.1	80.6	1417.1		.99
New York	29.8	14.7	28.5	11.9	22.7	13.4	78.0	1339.6		1.11
New Jersey	30.5	12.9	26.7	10.8	17.0	11.9	77.6			1.09
Pennsylvania	31.0	12.6	28.0	10.6	20.1	13.0	73.0	1205.3		1.14
Delaware	19.2	11.6	21.1	8.3		14.3	66.3			1.04
Maryland	24.1	12.2	20.1	10.3	25.5	13.0	67.8	662.7		1.07
Virginia	16.8	8.2	11.9	6.9	16.1	10.8	60.7	596.1	158.9	1.10
North Carolina	12.2	6.0	9.5	5.8	11.0	9.7	60.7	480.8	180.7	1.16
South Carolina	9.4	5.7	10.3	4.6	14.2		55.0		157.8	1.15
Georgia	10.5	6.0	9.8	5.5	14.0		58.8		145.9	1.23
Florida	9.7		10.2				68.3		106.4	.98
Alabama	12.7	6.0	10.8	5.5	10.4		62.1		140.1	1.21
Mississippi	14.3	5.7	11.0	6.5			62.3		194.4	1.28
Louisiana	16.0		12.5	8.3			62.8		232.7	1.22
Texas	18.0	10.0	23.4	9.7	15.9		62.5		199.1	1.26
Arkansas	19.7	7.5	16.9	7.4			68.5	578.0	229.8	1.23
Tennessee	20.6	6.7	13.7	6.2	13.4	8.5	59.2	645.4	189.2	1.21
West Virginia	23.4	10.2	17.7	8.5	19.3	10.0	65.7	609.5		1.01
Kentucky	23.8	9.4	18.2	9.0	21.0	9.5	61.3	755.2		1.16
Ohio	30.9	13.6	30.9	12.0	20.6	11.0	68.7	912.8		1.21
Michigan	28.9	15.2	32.3	12.0	23.1	13.3	76.7	503.6		1.23
Indiana	28.9	13.1	27.5	11.4	21.8	10.4	66.0	721.7		1.27
Illinois	26.7	13.4	34.2	15.5	21.0	10.3	71.9	651.9		1.29
Wisconsin	27.2	12.0	30.4	13.4	22.7	10.3	81.9	967.2		1.17
Minnesota	29.6	12.5	33.1	14.5	23.1	10.5	92.3			1.32
Iowa	30.9	10.6	32.3	12.9	21.8	10.9	79.3			1.22
Missouri	27.4	11.7	26.0	11.8	20.3	11.4	70.3	802.4		1.20
Kansas	28.5	13.9	28.0	15.2	18.9	11.1	66.7			1.28
Nebraska	32.8	11.1	29.1	13.8	19.6	10.2	74.1			1.31
California	27.9	12.5	26.2	10.5	20.4	20.8	86.8			1.39
Oregon	23.8	16.3	27.9	15.9	26.0	14.2	100.0			1.39
Nevada	24.6	17.6	29.8		22.2		91.1			1.24
Colorado	26.7	19.5	31.2	17.1	24.5		89.3			1.25
Arizona	20.9	13.8			19.2		63.8			1.07
Dakota	25.4	11.9	27.7	14.9	21.3	11.3	85.0			1.30
Idaho	23.2	17.1	30.9	13.0	27.2		101.3			1.19
Montana	26.6	17.6	32.6		27.2		107.4			1.15
New Mexico	19.9	13.6	22.7		19.6		78.3			1.08
Utah	19.7	17.2	26.6	10.8	22.6		90.5			1.28
Washington	24.3	17.0	36.0	15.1	29.1		117.1			1.31
Wyoming		18.0	29.7				95.5			1.17
Average	24.1	12.0	26.6	11.9	21.7	12.8	76.2	727.1	168.1	1.19

IMPORTS AND EXPORTS OF AGRICULTURAL PRODUCTS.

The official records of foreign trade for the fiscal year 1890 show an increase in the total exports from this country over last year of $115,011,219, changing the balance of trade, which was against us in 1889 by $14,849,043, to one in our favor of $55,983,419. The importance of the farmer in our foreign commerce is emphasized by the fact that the product of his labor last year furnished 74.2 per cent of our total shipment abroad, while 47.4 per cent of our imports were of agricultural products. During 1889 the balance in favor of our farmers in this international exchange of farm products amounted to $174,000,000, but the transactions of 1890 leave a still more gratifying balance on the credit side of the ledger amounting to $253,000,000. This at least is the apparent balance, though the real difference is much less, for the value of exports includes transportation to seaboard,

and that of imports is increased by the cost of sea and land transportation from foreign countries.

The greater part of our increase in exports was made up of the increase in agricultural products, which amounted to $97,000,000. This enlargement of the foreign market for our agricultural surplus was especially gratifying, coming at a period when our farmers were beginning to feel keenly the decline in agricultural values which was prevailing in all portions of the world. More than one half of the increased demand was for animals and their products, the sales of cattle alone amounting to $15,000,000 more than in the previous year. Beef products contributed $7,000,000 to the increase, while our pork products, though partially barred from some countries, showed a still more striking increase, amounting to $20,000,000.

The shipments of breadstuffs showed an advance in value over the previous year of $31,000,000, wheat contributing about one half. An encouraging feature of this branch of the trade was the increase of $10,000,000 in shipments of corn and $4,000,000 in oats.

The increase in agricultural imports was not in proportion to the total increase of imports, but aggregated $18,000,000. Of this increase sugar furnished $8,000,000, tea and coffee $4,000,000, and tobacco $7,000,000, while numerous other products show smaller gains. There was a marked falling off in value of hides, wool, and hemp imported. As our agriculture becomes more diversified, and our range of successful cropping more extended, the balance of foreign exchange in favor of our agriculture will become more pronounced. Sugar is now the largest item purchased abroad, and our present activity and success in the line of beet, cane, and sorghum experiments indicates a speedy curtailment of the amounts paid each year for foreign sugars.

The following tables present in itemized form our foreign trade in agricultural products for two years past:

IMPORTS.

Articles.	1889.	1890.
Sugar and molasses:		
Sugar	$88,543,971	$96,094,532
Molasses	4,753,897	5,168,795
Sugar drainings	4,026	3,999
Total sugar and molasses	93,301,894	101,267,326
Tea, coffee, and cocoa:		
Tea	12,654,640	12,317,493
Coffee	74,724,882	78,267,432
Cocoa, crude, and leaves and shells of	2,142,061	2,312,781
Unenumerated items	337,739	556,931
Total tea, coffee, and cocoa	89,859,322	93,454,637
Animals and their products, except wool:		
Cattle	703,469	244,747
Horses	4,868,862	4,840,485
Sheep	1,259,000	1,268,209
All other and fowls	392,712	413,491
Bristles	1,284,724	1,286,219
Butter	24,577	13,679
Cheese	1,135,184	1,295,506
Eggs	2,418,976	2,074,912
Glue	454,460	471,829
Grease	212,198	264,629
Hair	2,585,941	3,026,586
Hides	25,127,750	21,881,886
Hide cuttings, etc	232,251	348,440
Hoofs, horns, etc	303,575	236,648
Meats—		
Preserved	329,411	407,038
All other	199,734	196,696

IMPORTS—Continued.

Articles.	1889.	1890.
Milk, preserved or canned	$85,485	$98,395
Oil, animal	3,677	6,471
Sausage skins	377,750	494,958
Unenumerated items	263,278	490,648
Total animals and their products, except wool	42,263,014	39,361,472
Fibers:		
Animal—		
Wools	17,974,515	15,264,083
Silk, unmanufactured	19,333,229	24,331,867
Vegetable—		
Cotton	1,194,505	1,392,728
Flax	2,070,729	2,188,021
Hemp and all substitutes	9,433,774	7,341,956
Jute	2,853,664	3,249,926
Sisal grass and other vegetable substances	6,110,308	7,064,184
Fibers not elsewhere specified	483,212	697,680
Total fibers	59,453,936	61,530,445
Miscellaneous:		
Breadstuffs—		
Barley	7,723,838	5,629,849
Corn	1,216	908
Oats	10,178	8,950
Oatmeal	56,002	59,300
Rye	24	115,657
Wheat	119,017	112,303
Wheat flour	5,792	5,049
Breadstuffs and farinaceous substances not elsewhere specified	1,055,655	1,210,982
Chicory	216,573	209,283
Fruits and nuts	18,746,417	20,746,471
Hay	1,082,885	1,143,445
Hops	1,155,472	1,053,616
Indigo	2,684,105	1,827,937
Ivory, vegetable	96,574	61,477
Malt, barley	111,381	161,666
Oils, vegetable:		
Fixed or expressed—		
Olive	696,065	819,110
Other	1,108,854	1,340,551
Volatile or essential	1,183,005	1,061,631
Opium, crude	1,454,097	1,183,712
Plants, trees, and shrubs	325,331	343,226
Rice and rice meal	3,499,437	2,540,674
Seeds	5,097,223	4,089,814
Spices:		
Ground	173,668	249,077
Unground—		
Nutmegs	514,888	534,340
Pepper	1,578,421	1,619,215
All other	890,889	820,439
Tobacco, leaf	10,868,226	17,605,192
Vanilla beans	699,903	559,867
Vegetables:		
Beans and pease	786,343	1,307,702
Potatoes	321,106	1,365,898
Pickles and sauces	349,422	386,307
All other—		
In their natural state or in salt or brine	423,124	885,390
Prepared or preserved	389,804	510,077
Wines:		
Champagne and other sparkling	4,254,413	4,752,572
Still wines—		
In casks	2,126,548	2,450,174
In bottles	1,325,811	1,657,210
Unenumerated items	123,187	148,491
Total miscellaneous	71,254,894	78,577,562
RECAPITULATION.		
Sugar and molasses	93,301,894	101,267,326
Tea, coffee, and cocoa	89,859,322	93,454,637
Animals and their products, except wool	42,263,014	39,361,472
Fibers, animal and vegetable	59,453,936	61,530,445
Miscellaneous	71,254,894	78,577,562
Total agricultural imports	356,133,060	374,191,442
Total imports	745,131,652	789,310,409
Per cent of agricultural matter	47.8	47.4

EXPORTS.

Articles.	1889.		1890.	
	Quantities.	Value.	Quantities.	Value.
Animals, living:				
Cattle ..... number..	205,786	$16,616,917	394,836	$31,261,131
Hogs ..... do....	45,128	356,764	91,148	909,042
Horses ..... do....	3,748	592,469	3,501	680,410
Mules ..... do....	2,980	356,333	3,544	447,108
Sheep ..... do....	128,852	366,181	67,521	243,077
All other and fowls	.....	86,141	.....	97,360
Animal matter:				
Bones, hoofs, horns and horn tips, strips, and waste	.....	242,429	.....	271,533
Casings for sausages	.....	510,114	.....	697,772
Eggs ..... dozen..	548,750	75,936	380,884	58,675
Glue ..... pounds..	534,203	72,283	728,696	88,484
Grease, grease scraps, and all soap stock	.....	827,876	.....	1,506,819
Hair and manufactures of	.....	388,731	.....	344,558
Hides and skins other than furs	.....	909,798	.....	1,828,635
Honey	.....	93,888	.....	113,101
Oils:				
Lard ..... gallons..	861,303	542,897	1,214,611	663,343
Other animal ..... do....	558,080	377,919	727,732	457,926
Meat products—				
Beef products—				
Beef, canned ..... pounds..	51,025,254	4,375,213	82,638,507	6,787,193
Beef, fresh ..... do....	137,895,391	11,481,861	173,237,596	12,862,384
Beef, salted or pickled .. do....	55,006,399	3,043,324	97,508,419	5,250,068
Beef, other cured ..... do....	194,036	17,819	102,110	9,223
Tallow ..... do....	77,844,555	3,942,024	112,745,370	5,242,158
Mutton ..... do....	296,220	25,995	256,711	21,793
Oleomargarine—				
Imitation butter ..... do....	2,192,047	250,605	2,535,926	297,264
The oil ..... do....	28,102,534	2,664,492	68,278,098	6,476,258
Pork products—				
Bacon ..... do....	357,377,399	29,872,231	531,899,677	39,149,635
Hams ..... do....	42,847,247	4,779,616	76,591,279	7,907,125
Pork, fresh ..... do....	22,794	1,662	279,463	15,406
Pork, salted or cured .. do....	64,110,845	4,733,415	79,788,868	4,753,488
Lard ..... do....	318,242,990	27,329,173	471,083,598	33,453,520
Poultry and game	.....	9,827	.....	23,365
All other meat products	.....	876,161	.....	931,770
Dairy products—				
Butter ..... pounds..	15,504,978	2,568,765	29,748,042	4,187,489
Cheese ..... do....	84,999,828	7,889,671	95,376,053	8,591,042
Milk	.....	260,590	.....	303,325
Wax, bees' ..... pounds..	99,917	23,918	171,391	19,727
Wool, raw ..... do....	141,576	23,065	231,042	33,543
Total value of animals and animal matter	.....	126,586,103	.....	175,987,350
Bread and breadstuffs:				
Barley ..... bushels..	1,440,321	853,490	1,048,311	754,605
Bread and biscuits ..... pounds..	14,494,880	749,652	15,035,540	766,476
Corn ..... bushels..	69,592,929	32,982,277	101,973,717	42,658,015
Cornmeal ..... barrels..	312,186	870,485	361,248	896,879
Oats ..... bushels..	624,226	245,562	13,692,776	4,510,055
Oatmeal ..... pounds..	10,210,413	273,173	25,460,322	784,879
Rye ..... bushels..	287,252	158,917	2,257,377	1,279,814
Rye flour ..... barrels..	3,669	13,370	3,933	13,782
Wheat ..... bushels..	46,414,129	41,652,701	54,387,767	45,275,906
Wheat flour ..... barrels..	9,374,803	45,296,485	12,231,711	57,036,168
All other breadstuffs and preparations of, used as food	.....	780,549	.....	949,348
Total value of bread and breadstuffs	.....	123,876,661	.....	154,925,927
Cotton and cotton-seed oil:				
Cotton—				
Sea island ..... pounds..	6,419,569	1,391,495	9,220,819	2,280,717
Other unmanufactured ..... do....	2,378,397,100	236,383,775	2,462,579,034	248,688,075
Cotton-seed oil ..... gallons..	2,690,700	1,298,609	13,384,385	5,291,178
Total value of cotton and cotton-seed oil	.....	239,073,879	.....	256,259,970

EXPORTS—Continued.

Articles.	1889.		1890.	
	Quantities.	Value.	Quantities.	Value.
Miscellaneous:				
Broom corn		$152,542		$111,147
Fruits and nuts—				
Apples, dried ..pounds..	22,102,579	1,201,070	20,861,462	1,038,682
Apples, green or ripe ....barrels..	942,406	2,249,375	435,506	1,231,436
Fruits, preserved—				
Canned		915,341		698,321
Other		52,048		59,401
All other, green, ripe, or dried		621,390		1,003,846
Nuts		32,360		27,861
Hay ....tons..	21,928	388,777	36,274	567,558
Hops ....pounds..	12,589,262	2,823,832	7,540,854	1,110,571
Oil-cake and oil-cake meal ....do....	588,317,880	6,927,912	711,704,373	7,999,926
Oils—				
Linseed ....gallons..	72,451	42,759	89,288	55,036
Other vegetable		55,812		102,792
Rice ....pounds..	439,706	24,124	388,914	20,728
Seeds—				
Clover .... do....	34,253,137	3,110,583	26,500,578	1,762,034
Cotton ....do....	11,373,865	119,279	7,660,601	74,575
Flaxseed or linseed .....bushels..			14,678	19,792
Timothy ....pounds..	10,200,673	451,728	11,051,053	473,770
All other		192,914		307,717
Tobacco—				
Leaf ....pounds..	211,521,051	18,546,991	244,343,740	21,149,869
Stems and trimmings ......do....	12,238,181	354,077	11,303,286	329,687
Vegetables—				
Onions ....bushels..	75,074	63,780	80,275	72,760
Pease and beans ....do....	294,456	560,574	261,212	558,317
Potatoes ....do...	471,955	316,224	406,618	269,693
Vegetables, canned		311,254		231,265
All other, including pickles		198,120		225,060
Wine—				
In bottles ....dozen..	7,311	33,000	7,281	32,350
Not in bottles ....gallons..	372,350	236,488	393,323	238,580
All other agricultural products		228,399		271,235
Total value of miscellaneous products		40,210,753		40,044,009
RECAPITULATION.				
Animals and animal matter		126,586,103		175,986,750
Bread and breadstuffs		123,876,661		154,925,927
Cotton and cotton-seed oil		239,073,879		256,259,970
Miscellaneous products		40,210,753		40,044,009
Total agricultural exports		529,747,396		627,216,656
Total exports		730,282,609		845,293,828
Per cent of agricultural matter		72.5		74.2

NOTE.—In this compilation of domestic agricultural exports sugar and molasses are not included because they are mainly reëxports of foreign production. The totals differ from those given by the Bureau of Statistics of the Treasury Department, they having included sugar and molasses, "ginseng and roots, herbs and barks not otherwise specified," and glucose, or grape sugar.

FOREIGN DISTRIBUTION OF CEREALS.

We have practically no surplus of cereals except wheat and corn. A large quantity of corn might be spared were there a foreign market for it. Wheat, in the form of grain and flour, is the principal cereal for the foreign trade. Where is it wanted? The record of the last fiscal year, 1889-'90, makes the foreign shipment of wheat unmanufactured 54,387,767 bushels, and of wheat in the form of flour 55,042,703 bushels, or a total of 109,430,470 bushels, which was 22.3 per cent of the estimated crop. Of this aggregate 78.2 per cent went direct to Europe; 5.7 per cent to Canada, most of which was ultimately added to the European supply. Central and South America took 8 per cent; the Islands of the Seas 5.6 per cent; and

the great continents of Asia, Africa, and Australasia only 2.5 per cent, or 2,725,098 bushels, which includes our wheat supplies to these continents and nearly two thirds of the population of the world. A single county of Dakota could supply from its surplus this requirement, and in any good season each of five principal counties could do it easily, viz, Brown, Cass, Grand Forks, Pembina, and Walsh, and possibly each of several others, and yet all the back counties of the two Dakotas are rushing forward in their search for more markets of more continents to conquer. It is an ambition that has already seriously reduced the price of wheat of the United States.

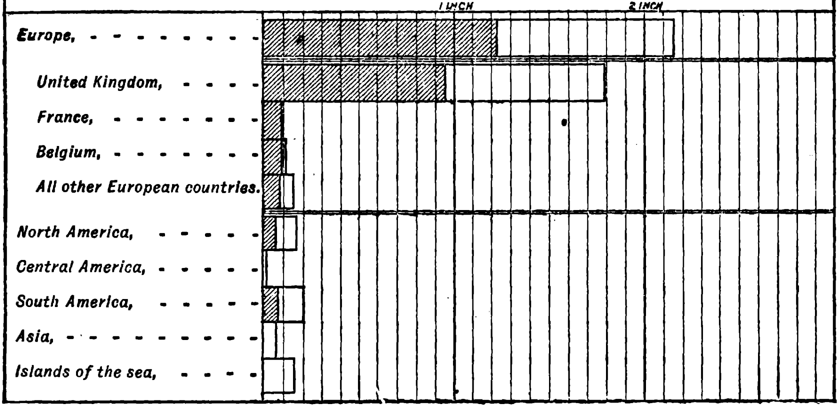
The details of this distribution are presented by countries, as follows:

Countries.	Grain.	Flour as wheat.	Total wheat.	Grain.	Flour.	Total.
				Per cent.	*Per cent.*	*Per cent.*
Europe	49,069,570	36,616,811	85,686,381	44.8	33.4	87.2
United Kingdom	38,240,523	33,407,946	71,648,469	34.9	30.5	65.4
France	3,846,505	1,274	3,847,779	3.5	....	3.5
Belgium	3,741,303	765,423	4,506,726	3.4	.7	4.1
All other European countries	3,241,239	2,442,168	5,683,407	3.0	3.2	5.2
North America	2,295,043	3,916,787	6,211,830	2.1	3.6	5.7
Central America	56,215	810,410	866,625	.1	.7	.8
South America	2,687,333	5,143,838	7,831,171	2.5	4.7	7.2
Asia	23	2,492,829	2,492,852	....	2.3	2.3
Africa	37,805	53,393	91,198	....	....	....
Australasia	67,990	73,058	141,048	.1	.1	.2
Islands of the Sea	173,788	5,935,577	6,109,365	.2	5.4	5.6
Grand total	54,387,767	55,042,703	109,430,470	49.8	50.2	190

To enforce the attention of the most casual reader to the meaning of this unequal distribution and throw a strong light upon the practical worthlessness of the world's markets for wheat, unless an exception be made of Liverpool, a diagram has been prepared which requires only a glance to make the subject clear as sunlight.

DISTRIBUTION OF SURPLUS WHEAT OF THE UNITED STATES.

Scale, 34 million bushels per inch. Shaded portion, Wheat in grain. Unshaded portion, Flour.



The exports of corn for the year ended June 30, 1890, and the principal countries receiving it, are as follows:

Countries to which exported.	Bushels.
Great Britain	54,657,198
France	8,481,689
Germany	11,419,063
Belgium	4,800,295
Denmark	5,788,733
Netherlands	3,367,823
All other European countries	1,091,745
Total to Europe	89,606,546
All other countries	13,812,163
Total	103,418,709

It is proper to observe that this is the largest quantity of corn ever exported in a single year; nearly all as grain, or 101,973,717 bushels, the remainder being corn meal, 361,248 barrels, reduced to grain on the basis of 4 bushels per barrel. More than half of the meal went to Canada.

The reason why last year's shipments were so large is solely the fact that the export price was the lowest known since 1850. The average was 41.8 cents per bushel. The next largest exportation was in 1879–'80, 99,572,329 bushels, when the export price was very low, or 54.3 cents per bushel. As might be expected, the smallest exportation in the last forty years was 1,392,115, exclusive of meal, when the price was 93 cents. There were two or three years between 1860 and 1870 when the price was higher in currency, but not in gold. The exportation of corn depends upon its price in this country, as set by the demands of home consumption. The latest illustration of this fact is seen in the exports of December, 1890, which amounted to 1,594,588 bushels, valued at 60.3 cents per bushel, while the exports of December, 1889, were 6,421,352, valued at 43.2 cents per bushel. The proportion of last year's exportation, taken outside of Europe, was only 13.4 per cent, almost exactly the proportion of the previous year's smaller shipments. Either McLean or Livingston County, Illinois, usually produces nearly as much as all the corn taken by the markets of the world outside of Europe in the year of most extensive exportation. As this country produces three fourths of all the corn of the world, and consumes more than twice as much as all other countries combined, it will require much missionary effort and experimental teaching in the preparation of a maize dietary to induce foreigners to make use of corn for food. It is only wanted now when very cheap, as a constituent in the feed rations of horses and cattle, and only to a very limited extent, by a few buyers in Western Europe. An increase in European requirements, from consumption as food, would benefit the consumer abroad far more than the producer in this country.

SUGAR PRODUCTION IN EUROPE.

The evolution of the beet-sugar manufacture is a growth of the present century. It was fostered early in the century by science and government through invention and bounty, yet half of its development has occurred during the last decade. Profiting by Euro-

pean experience, this country has a less difficult problem to solve. There have been no satisfactory experiments in the manufacture here until the success at Alameda in California. Those of Maine, Wisconsin, and Illinois were preliminary and inconclusive. They were necessarily failures from lack of skill and completeness of preparation, and still more from failure of farmers to coöperate. In the Maine case the average contracts were for only a fraction of an acre, a garden patch receiving ordinary field cultivation, without knowledge of the necessary culture or fertilization, without the adjunct of cattle-feeding and utilization of the by-product.

Now there promises to be a revival of the experiment since the repeated successes in California, with high promise of continued enlargement. Nebraska has already entered the lists. It would be a craven and ignominious acknowledgment to admit that the manufacture can be carried on successfully throughout Europe and can not be a success upon the continent of North America, when a good yield of beets having a high content of sugar has been repeatedly grown from the Atlantic to the Pacific, and good sugar has been made year after year at a profit.

There are many intelligent citizens, even some newspaper editors, who are entirely unaware of the fact that half the commercial sugar of the world is made of beet, on a continent where cane can not be grown, and no other source of sugar is extensively available, and especially oblivious of the fact that cane sugar is practically barred entrance into Europe, because the home product of beet sugar leaves no room for it. This general proposition has been vigorously assailed in the public press, though the facts show that for several years the continent of Europe, exclusive of the British Isles, has exported more than its imports. Indeed, few except those who keep abreast of the statistical situation in sugar production are fully aware of the recent development of the industry. The past season, if Licht's estimate is reliable, the production (3,627,967 metric tons) is ample for the consumption of Great Britain and the continent together. The progress of beet-sugar manufacture in Europe in thirteen years, according to the authority quoted, is shown by the following figures of production, which are stated in metric tons of 2,204.6 pounds.

Years.	Germany.	France.	Austria-Hungary.	Russia and Poland.	Belgium.	Holland and other countries.	Total.
1877-'78	383,828	398,132	330,792	220,000	63,075	25,000	1,420,827
1878-'79	420,686	432,634	405,906	215,000	69,957	30,000	1,574,183
1879-'80	411,625	277,912	406,375	225,000	58,017	25,000	1,403,929
1880-'81	594,223	333,614	498,082	250,000	68,626	30,000	1,774,545
1881-'82	644,775	393,269	411,015	308,779	73,136	30,000	1,860,974
1882-'83	848,124	423,194	473,000	284,391	82,703	35,000	2,146,412
1883-'84	986,402	473,676	445,952	310,000	106,586	40,000	2,362,616
1884-'85	1,155,000	308,400	557,500	386,400	88,450	50,000	2,545,750
1885-'86	825,050	299,400	377,000	540,600	48,400	37,500	2,127,950
1886-'87	950,000	500,000	525,000	475,000	80,000	50,000	2,580,000
1887-'88	959,156	392,824	428,616	441,342	140,742	119,260	2,481,940
1888-'89	990,604	466,767	523,242	526,387	145,804	133,040	2,785,844
1889-'90	1,264,607	787,989	753,078	465,000	221,480	135,813	3,627,967

Germany produces about one third, heading the list of producing countries. Austria and France are large producers, and Russia has more than doubled production in a dozen years. The average product of four years, prior to the campaign just closed, is 2,493,936

metric tons, or 5,498,131,306 pounds. A comparison of imports and exports shows that this product more than sufficed for the consumption of the continent. The net exports of recent years average nearly 1,500,000,000 pounds, making the consumption about 4,000,000,000 pounds annually. With increase of production and prevailing cheapness, however, consumption is doubtless now increasing materially. The rate of consumption differs greatly in the different countries, being very low in Russia and Italy, Spain and Portugal; much larger for France and Germany and Scandinavia, though these countries scarcely use a third as much as Great Britain.

For the purpose of closely approximating the annual consumption of sugar in Europe, and of determining how much, in recent years, is beet sugar and how much cane sugar, the customs records of 1886 to 1888, inclusive, have been searched, and imports and exports of each country ascertained and reduced to pounds from the original kilograms, hundred weights, poods, and other measures. An annual average of three years eliminates much of the effect of the annual fluctuation, and determines more closely the annual consumption, which is made up of the two elements—production and importation.

The following table shows, for the years indicated, the average annual imports of sugar into the countries named, with the average annual exports therefrom for the same periods respectively. It also shows the net imports or the net exports, as the case may be, for each country, with the general net imports for the whole of Europe.* The figures for Austria-Hungary, Germany, Roumania, and Switzerland include molasses, and to that extent overstate the sugar trade. All the figures are taken directly from the official documents of the respective countries with the exception of those for Russia and Switzerland, which are from the British "Statistical Abstract for the Principal and other Foreign Countries." The foreign denominations are here reduced to their equivalents in pounds:

Countries.	Years.	Annual average.			
		Imports.	Exports.	Net imports.	Net exports.
		Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Austria-Hungary	1886, 1887, and 1888	2,362,964	515,840,906		513,477,942
Belgium	do	30,164,776	218,921,270		188,756,494
Denmark	do	41,477,309	5,284,461	36,192,848	
France	do	387,578,141	337,925,353	49,652,788	
Germany	do	15,541,695	1,397,216,691		1,381,674,996
Great Britain and Ireland	do	2,697,017,456	111,136,032	2,585,881,424	
Greece	1887 and 1888	14,937,983		14,937,983	
Italy	1886, 1887, and 1888	174,577,644	219,137	174,358,507	
Netherlands	1887 and 1888	232,828,738	209,201,115	23,627,623	
Portugal	1886, 1887, and 1888	54,358,528		54,358,528	
Roumania	1885 and 1886	19,909,333	1,976	19,907,357	
Russia	1885, 1886, and 1887		130,885,550		130,885,550
Spain	1886, 1887, and 1888	116,962,663	8,914	116,953,749	
Sweden and Norway:					
Sweden	1885, 1886, and 1887	86,730,728	101,392	86,629,336	
Norway	1886, 1887, and 1888	26,089,692	1,031,290	25,058,402	
Switzerland	1885, 1886, and 1887	77,167,099		77,167,099	
Total		3,977,704,749	2,927,774,087	3,264,725,644	2,214,794,982

This table shows that the continent has had, for three years at least, a surplus sufficient for more than half of the requirements of

* Montenegro, Servia, and Turkey, with its tributary States, are the only European countries not included. For these no statistics are available.

consumption in Great Britain. The details of exportation of Germany and other beet-sugar countries show that the larger portion of their shipments abroad goes to Great Britain. The difference between these aggregates of exports and imports, 1,049,930,662 pounds, is presumed to represent approximately the share of cane sugar in recent consumption, say one sixth to five sixths of beet sugar. At the same time the past year's product is more than a million tons in excess of the consumption of the continent and British Isles together; the excess over recent years is twice as much as the net importation into Europe. In view of this fact, it is safe to say, for the present at least, that in Europe production has outrun consumption, with a prospect of having a constant surplus for other continents.

The farmers of the country have some responsibility in the development of the sugar industry. The product can not be made without beets, which must come from the fields of the farms. The value of the roots depends upon their content of sugar, which depends in turn upon seed, soil, fertilization, and cultivation. This difference may vary a dollar or more per ton and represent all the possible profit in their production. Hence the farmer has a large stake in the skill and technical knowledge which yields the best results. As he must learn the requirements of the plant and the details of its treatment, he must not expect to escape reduction of his profits as a necessary penalty for the blunders of his apprenticeship. The most extensive preparations for beet-sugar production, east of the Rocky Mountains, were made this season at Grand Island, Nebraska, and Medicine Lodge, Kansas. At the latter place beet sugar was made last year. The results in Nebraska are so favorable that new plants and more extended operations are planned.

The prevailing error in agricultural practice, as in some other lines of effort in this country, is to look only to the present hour, and get the largest return to-day, without a thought of the future. The beet-sugar industry involves something more than the price of a ton of beets the present year. It includes—

(1) Rotation, which insures large yields and clean cultivation.

(2) Symmetry in rural development, variety in production.

(3) Fertilization, providing in large degree the material through cattle feeding.

(4) Fine tilth and thorough cultivation.

(5) Increased value of land, from its enlarged capacity for production, and the cheapening of cost of product and resulting increase of net profit.

It would be easy to show the relative advance in value of lands in beet-sugar districts, the increase of agricultural wealth, and the general prosperity enhanced by this industry. Rotation is a necessity, the soil must be enriched, though fertilizers must be applied to preceding crops and not to the crop of beets directly. Sugar-beet culture is only one link in the chain of production which gives variety and prosperity to agriculture.

AGRICULTURE OF CANADA.

The Dominion of Canada comprises the provinces of Quebec, Ontario, Nova Scotia, New Brunswick, Manitoba, British Columbia, Prince Edward Island, and the Northwest territories. It comprises the whole northern half of North America, except Alaska on the

west, and Labrador, which belongs to the Government of Newfoundland, on the east, and in extent of territory is nearly as large as the States. The area of the whole continent of Europe exceeds it by less than 250,000 square miles. Such a comparison, however, is of little consequence, as a very large proportion of this vast territory lies in a cold, inhospitable climate, not suitable for habitation by civilized man, along the shores of the Northern Ocean and portions of Hudson Bay.

The area of the Dominion is so great that its general features of soil and climate are wonderfully varied, ranging from smiling and fertile agricultural areas to barren wastes, and from meteorological conditions resembling those which prevail over the British Isles to those of the Arctic region. Vast forests once covered practically the whole of Canada from the Atlantic Ocean to the Northwest boundaries of the Province of Ontario, and the face of the country in some districts is yet heavily wooded, the wealth of timber being one of the principal resources of many of the provinces. The soil underlying this virgin forest has been found very fertile and well adapted to a varied agriculture.

No census of the population of the Dominion has been taken since April 4, 1881, when it aggregated 4,324,810, an increase of 18.97 per cent during the preceding ten years. This census returned 1,390,604 persons as engaged in some occupation, or slightly more than one third of the total population. The proportion is almost exactly the same as the census of 1880 returned for this country, and the figures show that among the people of both countries there are very few drones in the national hive. Classifying the occupations of the people in accordance with our own classifications, the proportion engaged in different occupations in each country is as follows:

Occupations.	Canada.	United States.
Agriculture	55.9	44.1
Trade and transportation	9.1	10.4
Industrial	24.2	22.1
Professional and domestic	10.8	23.4

This statement would seem to show that the distribution of the workers of the two countries in trade and industrial pursuits is in about the same proportion, but there is a marked disparity in the proportions engaged in rural and professional pursuits. Considerably more than half of the Canadian population is dependent upon the bounty of the soil, a proportion too large for that harmonious development of resources necessary to the highest national prosperity.

Canada is essentially an agricultural country. The staple products are wheat, barley, oats, pease, corn, hay, potatoes, turnips, and live stock. But the lack of data of production for some provinces makes it impossible to present detailed estimates of the crops of the Dominion. It appears that the annual wheat crop amounts to between 35 and 40 million bushels, of which Ontario and Manitoba grow the largest proportion. The soil of these districts is admirably adapted to the cultivation of this cereal. The fields of Manitoba adjoin and are much similar to the American wheat districts of the Red River Valley and North Dakota, in Dakota, and the natural productiveness of this district is hardly exceeded by any wheat fields of the world. Oats

make up the largest bulk of the grain crops of the Dominion, this cereal flourishing best near the northern limit of its habitat. Barley is the cereal grown for foreign markets, the soil and climate being admirably adapted to its cultivation. The whole product of Canada has been estimated at 28,000,000 bushels. The United States has been the great market for Canadian barley; it is the only cereal which this country finds it necessary to purchase abroad. Taking the Canadian trade figures the following table is made showing the total shipment of home-grown barley during five years past and the amount of that total taken by the United States:

Years.	Total exports.	Taken by United States.
	Bushels.	*Bushels.*
1885	9,067,395	9,028,314
1886	8,554,302	8,528,287
1887	9,456,964	9,437,717
1888	9,370,158	9,360,521
1889	9,948,207	9,934,501

The foreign trade of the Dominion is carried on almost exclusively with the United States and Great Britain, the imports and exports to and from these two countries during 1887–'88 amounting to 88 per cent of the aggregate trade. A larger proportion of the exports alone went to these two countries, the proportion for the same years amounting to 91.52 per cent; Newfoundland, South America, and the West Indies took 5.95 per cent, leaving only 2.53 per cent to be divided among the remaining countries of the world. The trade with the United States alone amounts to almost half of the total, and yet, according to the official figures of this country, our trade with Canada constitutes only about 6 per cent of our total. In 1889 the Dominion records credit us with a balance of trade of $12,846,586, while the balance of trade in favor of Great Britain was only $4,144,429 for the same year. The records of our Government show a slight balance in favor of Canada. As this country, according to their records, ranks first in both the import and export trade of Canada, the following tables, prepared from the reports of the Bureau of Statistics of the Treasury Department, giving an itemized statement of the trade, exclusive of bullion for 1889, will be found interesting. The exports are of domestic merchandise only.

Items.	Quantity.	Value.
EXPORTS.		
Agricultural implements		$132,550
Animals, living		546,778
Breadstuffs		9,393,727
Coal ... tons	1,370,119	5,357,285
Cotton, raw ... bales	61,505	2,980,556
Hides and skins		451,171
Iron and steel, and manufactures of		2,383,147
Leather, and manufactures of		244,485
Illuminating oil ... gallons	4,838,779	479,499
Provisions		6,876,682
Tobacco, leaf ... pounds	3,843,473	732,810
Wood and manufactures		2,624,311
All other articles		6,076,043
Total		38,279,044

Items.	Quantity.	Value.
IMPORTS.		
Animals, living		$5,199,713
Barley ..... bushels	11,365,881	7,721,475
Coal ..... tons	434,741	1,842,466
Copper and copper ore		313,924
Eggs ..... dozen	15,370,061	2,345,715
Fish		2,765,521
Flax ..... tons	2,168	339,545
Hay ..... do	105,220	1,081,802
Malt, barley ..... bushels	136,256	100,314
Tobacco, leaf ..... pounds	816,197	421,795
Wood, and manufactures of		11,852,488
Wool ..... pounds	1,108,226	218,324
All other articles		7,746,139
Total		41,949,221

AGRICULTURE OF MEXICO.

The Government of Mexico publishes statistics of agricultural production, as follows:

Crop.	Value.	Producing States.
	Pesos.	
Cotton	10,857,000	Coahuila, Durango, Chihuahua, Vera Cruz, Colima, Jalisco, Guerrero, Michoacan, Oaxaca, Sonora, Tamaulipas, Nuevo Leon, and Hidalgo.
Rice	1,246,000	Vera Cruz, Colima, Michoacan, Chiapas, Guerrero, Oaxaca, Tampico, Sonora, Yucatan, and Morelos.
Indigo	372,910	Oaxaca, Chiapas, Guerrero, Vera Cruz, Sonora, and Colima.
Cocoa	1,135,360	Tabasco, Chiapas, Oaxaca, and Vera Cruz.
Coffee	3,200,000	Vera Cruz, Oaxaca, Morelos, Michoacan, Colima, and Chiapas.
Tobacco	2,500,000	Vera Cruz, Tabasco, Campeche, Yucatan, Chiapas, Oaxaca, Guerrero, Jalisco, Sinaloa, and Colima.
Cochineal	111,910	Oaxaca.
Vanilla	900,000	Vera Cruz, Oaxaca, Tamaulipas, Tabasco, Guerrero, Michoacan, Jalisco, and Colima.
Sarsaparilla	200,000	Vera Cruz.
Hennequen	3,718,750	Yucatan and Campeche.
Ixtle	700,000	
Cane or sugar	8,735,000	Morelos, Vera Cruz, Puebla, Oaxaca, and Yucatan.
Total special	33,676,930	
Maize	110,000,000	Mexico in general.
Beans	8,000,000	
Pease	450,000	
Chick pease	500,000	
Anise	105,000	
Barley	4,500,000	
Wheat	18,400,000	
Sesame	200,000	
French beans	500,000	
Allspice (Chili)	455,000	
Lentils	100,000	
Potatoes	600,000	
Total general	147,455,000	

The pesos is worth about 83 cents in our money. The products of the maguey plant, which are of considerable value, are not included, as also other minor products.

Valuable forest products are sources of considerable income, and will prove of great value in the future. Mahogany, ironwood, teak, ebony, cedar, logwood, and many other valuable woods abound. Among fruits may be mentioned the orange, lemon, citron, date, guava, pineapple, tamarind, banana, mangrove, melon, and many others.

SOUTH AMERICAN STATISTICS.

ARGENTINE REPUBLIC.

Previous to 1810 agriculture neither did nor could exist in the territories which now form the Argentine Republic, the cultivation of the principal cereals being then forbidden under Spanish law, with a view to compelling the colonists to obtain their breadstuffs from Europe. With the establishment of independence in the year named grain began to be cultivated a little, but it is only since the inauguration of the constitutional era (in 1853) that agriculture has begun to assume a certain importance.

The following table shows by provinces and territories, the area of cultivated land in the Argentine Republic, and the percentage which this land is of the total area:

Provinces and territories.	Area under cultivation.		Per cent of total area.
	Hectares.	*Acres.*	
Provinces:			
Buenos Ayres	932,591	2,304,432	3.1
Santa Fé	586,537	1,449,333	5.9
Entre Rios	136,151	336,429	1.7
Corrientes	46,631	115,225	1.3
Cordova	234,395	579,190	0.5
San Luis	19,869	49,096	0.2
Mendoza	88,546	218,797	0.5
San Juan	79,715	196,976	0.8
La Rioja	22,217	54,898	0.2
Catamarca	44,618	110,251	0.5
Santiago	120,400	297,509	1.2
Tucuman	35,943	88,815	1.5
Salta	40,256	99,473	0.3
Jujui	18,994	46,934	0.4
Territories:			
Missiones	4,606	11,382	0.1
Formosa	648	1,601	....
Chaco	3,623	8,953	....
Pampa Central	5,864	14,490	....
Rio Negro	1,291	3,190	....
Total	2,422,995	5,987,221	1.1

The areas under the various crops, with the percentage which each one forms of the total crop area, according to the agricultural and live stock census of October, 1887, are as follows:

Crops.	Areas cultivated.		Per cent of total area.
	Hectares.	*Acres.*	
Wheat	815,438	2,014,947	33.6
Maize	801,583	1,980,712	33.1
Alfalfa	390,009	963,712	16.1
Flax	121,073	299,171	5.0
Barley	28,672	70,849	1.2
Vines	23,345	57,685	1.0
Sugar cane	21,062	52,044	2.8
Potatoes	14,137	34,933	
Peanuts	6,794	16,788	
Kidney beans	6,775	16,741	
Manioc	4,742	11,717	
Sweet potatoes	3,757	9,284	
Canary seed	3,456	8,540	
Tobacco	3,234	7,991	
Oats	2,371	5,859	
Rice	1,286	3,178	
Vegetables and various crops	175,261	433,070	7.2
Total	2,422,995	5,987,221	100

It has been stated that the quantity of rainfall diminishes as the distance from the Atlantic increases, until finally irrigation becomes essential to successful agriculture. The following figures show the area irrigated, or suitable for irrigation by the construction of canals, so far as reported in the census:

Provinces and territories.	Area.	
	Hectares.	*Acres.*
Provinces:		
Buenos Ayres	115,351	285,032
Corrientes	18,893	46,685
San Juan	79,715	196,976
La Rioja	13,491	33,336
Catamarca	24,237	59,890
Tucuman	74,648	184,455
Salta	96,321	238,009
Jujui	67,271	166,227
Territories:		
Missiones	92	227
Pampa Central	58	143
Rio Negro	1,440	3,558
Total	*492,417	1,216,762

* The actual sum of the items given above is 491,517 hectares (1,214,538 acres).

The following comparison between 1877 and 1887 in respect to the quantities of some of the leading agricultural products exported in those two years, respectively, shows how rapid must have been the growth in agricultural production during the intervening decade.

Products.	Quantities exported in tons of 1,000 kilograms (2,204.6 pounds).		Products.	Quantities exported in tons of 1,000 kilograms (2,204.6 pounds).	
	1877.	1887.		1877.	1887.
Wheat	200	237,866	Flax	....	81,208
Flour	218	5,401	Potatoes	3	191
Maize	9,818	361,844	Bran	2,355	4,194
Barley	....	820	Hay	6,722	12,375

The following table shows the number of animals, by provinces, as returned by the live stock census of 1887:

Provinces and territories.	Sheep.	Cattle.	Horses.	Goats.	Asses and mules.	Swine.
Provinces:						
Buenos Ayres	51,557,750	8,482,483	1,691,192	10,198	31,058	208,088
Santa Fé	2,977,382	2,328,443	528,536	13,310	7,766	58,530
Entre Rios	4,901,123	4,120,068	719,510	13,846	6,518	23,523
Corrientes	611,085	1,841,455	268,699	16,603	13,506	10,021
Cordova	2,355,030	2,110,523	403,879	630,264	47,197	22,253
San Luis	241,827	478,904	113,554	310,491	27,769	6,844
Mendoza	122.298	180,009	44,849	50,847	11,184	6,552
San Juan	62,670	54,530	25,848	25,347	21,154	3,625
Rioja	57,932	160,197	25,038	108,188	30,824	5,252
Catamarca	152,432	239,834	56,054	190,806	89,402	10,962
Santiago	781,951	588,396	110,368	308.993	27,498	13,093
Tucuman	43,390	198,835	42,939	26,299	14,805	7,129
Salta	256,695	267,225	34,174	84,567	39,693	7,194
Jujui	617,803	89,855	22,896	77,975	46,425	2,358
Territories:						
Missiones	4,218	41,967	17,541	3,279	1,096	3,961
Formosa	143	14,403	625	50	44	437
Chaco	3,751	17,551	1,597	500	365	892
Pampa Central	1,670,393	469,775	110,104	12,467	1,140	2,147
Rio Negro	287,940	77,434	16,620	715	50	864
Tierra del Fuego	282	148	9	10	....	33
Total *	66,701,097	21,963,930	4,262,917	1,969,765	430,940	403,203

* The discrepancies between the sum of the items in each column and the totals given, appear in the original document.

There were 177,055 ostriches, of which 154,022 were in the province of Buenos Ayres, 10,077 in Corrientes, 4,787 in the Territory of Pampa Central, and the remainder scattered through various provinces and territories.

There were 47,738 llamas, of which all except 500, credited to Catamarca, were in the Province of Jujui, where they are used as beasts of burden.

Of cattle, sheep, and horses, as distributed into classes, there were the following numbers:

Classes of animals.	Cattle.	Sheep.	Horses.
Work animals	962,699	....	1,047,769
Range stock:			
Common	17,574,572	24,317,214	2,951,182
Mixed breeds	3,388,801	42,002,867	259,009
Pure breeds	37,358	381,016	4,957
Total	21,963,930	66,701,097	4,262,917

Of mules there are reported 116,700, and of asses 47,887, work animals, making together 164,587 work animals out of a grand total of 430,940 of these classes.

Of pure breeds there were 1,617 goats and 3,594 swine, and of mixed breeds 15,469 goats and 88,678 swine; while of ostriches there were 2,119 imported African birds and 25,406 obtained by crossing the African bird with the indigenous one, the remaining being of the indigenous variety.

The average weight of beef cattle on the coast is from 125 to 150 kilograms (276 to 331 pounds) for cows, and from 200 to 250 kilograms (441 to 551 pounds) for oxen. The average weight of sheep is from 20 to 25 kilograms (44 to 55 pounds) for ewes and from 30 to 35 kilograms (66 to 77 pounds) for wethers. In the interior provinces, cattle stabled during the winter, or pastured on alfalfa, obtain a much greater weight.

Estimated according to the average value for each class of animals, the total value for each class and for the entire number is stated as follows:

Class.	Values.	
	Pesos nacionales.	*Dollars.*
Cattle	289,252,606	173,551,563.60
Sheep	147,233,702	88,340,221.20
Horses	46,283,094	27,769,856.40
Asses and mules	4,569,866	2,741,919.60
Swine	3,703,454	2,222,072.40
Goats	2,409,183	1,445,509.80
Ostriches	1,111,143	666,685.80
Llamas	238,322	142,993.20
Total	494,801,370	296,880,822.00

The number of poultry is reported as follows:

Barnyard fowl	4,249,754
Peafowl	556,776
Ducks	318,648
Geese	184,699
Pigeons	954,487

The provinces of Buenos Ayres and Santa Fé are richest in poultry. The following table shows the quantities of the principal animal products exported in the years 1878 and 1888, respectively.

	1878.		1888.	
	Kilograms.	*Pounds.*	*Kilograms.*	*Pounds.*
Wool	81,894,174	180,543,896	131,743,339	290,441,365
Sheepskins	27,848,592	61,395,006	28,054,616	61,849,206
Goatskins	609,808	1,344,383	770,366	1,698,349
Horse hair	1,910,885	4,212,737	2,019,212	4,451,555
Tallow	21,097,022	46,510,495	14,802,873	32,634,414
Jerked beef	33,600,293	74,075,206	26,449,055	58,309,587
Hides, dry and salt:		*Number.*		*Number.*
Of cattle		2,238,802		3,306,620
Of horses		201,959		256,505

VENEZUELA.

Coffee stands first among the productions of Venezuela which have a recognized commercial importance, and with the advance in prices maintained for some years past, plantations have been greatly extended. The excellence of the Venezuelan coffee, and that grown in the eastern part of Colombia adjacent, which is marketed in Maracaibo and passes as a product of the former country, is well known and strengthens the demand.

It is understood that Java and Mocha of commerce are not the originals of these favorite names, and do not come from the East Indies or Arabia, but mainly, if not entirely, from South America, Venezuela taking high rank in their production. The "La Guayra" and "Maracaibo" are still imported, but rarely if ever now known under these names. Cacao is another product largely grown and exported. There is plenty of land suitable for its extension, but laborers for its cultivation are scarce. There are herds of cattle and flocks of goats, which furnish, besides milk, meat, and cheese to the population, hides and skins for export and cattle for some of the beef markets of some of the West Indian islands. The beef is always of inferior quality, as the grass it is fed upon is coarse, and there is no grain feeding. The cattle which arrive at or are produced near the coast for home meat market or for export would not be considered as in good "store" condition in the United States, and their meat is so tough that a beefsteak is fortunately unknown. It is divided for sale into chunks with a common ax, and so as to give to each customer impartially his share of the bones.

The latest statistics of live stock are for 1886, as follows:

Classes.	Number.	Classes.	Number.
Horned cattle	5,275,481	Swine	1,439,185
Goats and sheep	4,645,858		
Horses and mules	622,306	Total	12,752,750
Asses	769,920		

According to the best authority at hand the foreign commerce of Venezuela for 1888—the latest statement—amounted to a total of $35,387,551, in which her export excess was $3,802,235, showing very favorable conditions. This commerce, as to leading countries and

the value of their respective exports and imports, may be tabulated as follows:

Imports from—	Value.	Exports to—	Value.
Great Britain	*$4,702,023	United States	$9,123,099
United States	3,948,765	France	3,041,962
Germany	2,692,080	Germany	2,009,377
France	2,530,355	Great Britain	1,349,845
United States of Colombia	869,095	All others	3,241,491
All others	1,050,340		
		Total exports	19,594,893
Total imports	15,792,658	Total trade	35,387,551

* Of this amount only $2,907,335 was of British products.

It will be seen from the foregoing that the United States purchases from Venezuela nearly as much as all other countries combined, while Venezuela purchases of us only a little more than 25 per cent of her importations, but buys considerably more than twice as much from three European countries as from us.

Character and value of imports from Venezuela into the United States during the year ending June 30, 1889.

Articles free of duty.	Value.	Articles paying duty.	Value.
Animals	$70	Books, maps, etc	$1,559
Cacao or cocoa	138,753	Carpet wool	233
Cinchona	3,099	Copper ore	54
Cocoanuts	6,291	Copper bars	35
Coffee (63,114,529 pounds)	9,138,591	Drugs and dyes	334
Cotton	10,135	Fish	2
Drugs and dyes	72,343	Fruits, preserved	24
Dyewoods	18,252	Furniture	7
Furs and skins	87	Hats	30
Goatskins	330,969	Lead, manufactures of	187
Guano	71,690	Metal, manufactures of	25
Hides	530,913	Musical instruments	208
Household goods	50	Oranges	31
Resins and gums	483	Sheep	25
Rubber, crude	38,157	Spirits	12
Seeds	371	Zinc, spelter, etc	4,009
Spirits, distilled	1,211		
Vegetable ivory	120	Total dutiable	6,800
Woods	5,637	Add free articles	10,385,769
All other articles	18,547		
		Total imports	10,392,569
Total free of duty	10,385,769		

Classes and value of exports of domestic products from the United States to Venezuela during the year ending June 30, 1889.

Articles.	Value.	Articles.	Value.
Breadstuffs:		Provisions, as meats, etc.:	
Corn	$118,724	Bacon and hams	$70,393
Wheat flour	791,007	Butter	109,440
All other	79,858	Lard	477,036
Chemicals, drugs, dyes, etc	137,265	All other	17,162
Cotton, manufactures of	467,141	Tobacco and manufactures of	87,825
Iron and steel, manufactures of	442,450	Wood, manufactures of	94,351
Oils, mineral, refined	121,849	Other merchandise	690,104
		Total exports	3,701,605

COLOMBIA.

Coffee is the principal product of Colombian plantations. The product could be immensely increased but for the scarcity of labor.

Cinchona has been next in importance until recently. Hides and skins now rank second. Besides these, products for consumption and exportation are cacao, cocoanuts, sugar, bananas, tobacco, and occasionally cotton and corn. There are also some foreign shipments of India rubber, vegetable ivory, dyewoods, and gold and silver. Other products for home use are rice, yams, sweet potatoes, and Egyptian corn.

Of the rice produced, in the region of Cartagena, the berry is so small that machinery has not been secured with which to successfully clean it. Some wheat is grown on the highlands, but it is not popular because its flour can not be made into light bread. As to cereal cultivation generally, the habits of the people, their farming implements, and the climate are against it. The plow used in Colombia and most of the tropics is the primitive, single-handle, wood plow of Algeria and Moorish Spain, oftenest without an iron shod point, drawn by oxen yoked across the forehead firmly with a piece of timber and a rope or piece of rawhide; and although this instrument may disturb the soil, it helps as little as its owner towards reliable, steady husbandry, such as is known alone to less enervating climes. Iron and steel plows have been introduced on some plantations, but have been invariably broken by the laborers at night, and abandoned. Just so was the first tramway torn up in Puerto Cabello.

The latest census of farm and range stock gives the following numbers:

Kinds of stock.	Number.	Kinds of stock.	Number.
Neat cattle	949,072	Goats	610,147
Horses	140,735	Swine	343,542
Mules	41,520	Sheep	41,696
Asses	13,090		

An attempt to show the foreign trade of Colombia for 1888 was made by United States Minister Abbott, derived from his inspection of the customs returns of the country, and his reports, corrected by the Department of State upon the authority of the customs returns of this country, Great Britain, and France, and from the Statesman's Year-Book as to the trade of Germany, are the basis of the following tables. The indirect trade through France was with Belgium and Switzerland; that through the United States and Great Britain was with unascertained countries.

Imports of Colombia, 1888.

From—	Direct.	Indirect.	Total.
France	$7,874,000	$2,026,000	$9,900,000
Great Britain	5,236,000	272,000	5,508,000
The United States	4,923,259	100,621	5,023,880
Germany	1,010,304		1,010,304
The Antilles	225,701		225,701
Ecuador	171,147		171,147
Spain	122,156		122,156
Peru	16,690		16,690
Italy	9,824		9,824
All other countries	97,088		97,088
Total	19,686,169	2,398,621	22,084,790

Exports of Colombia, 1888.

Destination.	Value.	Destination.	Value.
United States	$1,393,258	Italy	$6,685
Great Britain	4,109,843	Spain	4,813
Germany	1,532,305	Ecuador	1,785
France ($9,036 Belgium)	1,159,894	Destination unknown:	
Antilles	181,220	Exports of Colon and Panama	1,682,293
Costa Rica	67,238	Exports of Ipeles and Cucuta	1,208,362
Venezuela	46,363		
Mexico	38,318	Total	14,551,076
Peru	18,699		

PAN-AMERICAN TRADE.

The interest manifested in the affairs of our neighbors of the Americas lying to the southward, and the importance of present trade relations with those countries, warrant a careful preparation of the facts of commercial exchanges with them. The following figures are taken from the official records of the Treasury Department, gathered by the Bureau of Statistics. The agricultural items in exports and imports are carefully segregated and presented separately. In the totals by countries the agricultural totals are placed side by side with the aggregates of all exports to or imports from the countries of South America, those of Central America, and the group of islands constituting the West Indies.

The following is a statement of our exports to the countries named and imports from those countries, during the last fiscal year:

Countries.	Agricultural.		Total.	
	Exports.	Imports.	Exports.	Imports.
	Dollars.	*Dollars.*	*Dollars.*	*Dollars.*
Central America:				
Costa Rica	351,366	1,380,382		
Guatemala	314,091	2,264,410		
Honduras	138,223	1,050,689	4,146,511	8,414,019
Nicaragua	283,413	1,016,099		
San Salvador	212,195	1,636,913		
British Honduras	191,448	180,524	362,623	211,465
Total	1,490,736	7,529,017	4,509,134	8,625,484
South America:				
Argentine Republic	304,102	5,193,741	8,376,077	5,454,618
Bolivia	2,100	1,477	762,546	....
Ecuador	275,672	480,797		695,005
Chili	341,763	1[illegible]3,492	2,967,254	2,622,625
Brazil	4,903,421	52,642,737	9,276,511	60,403,804
French Guiana	82,943	....	....	....
British Guiana	1,231,151	4,512,593	2,038,643	4,526,181
Dutch Guiana	171,760	458,925		460,243
Peru	112,531	202,965	773,244	314,032
United States of Colombia	984,115	3,669,996	3,728,961	4,263,519
Uruguay	360,412	2,847,828	2,027,38[illegible]	2,986,964
Venezuela	1,805,194	10,156,454	3,703,705	10,392,569
Total	10,575,164	80,271,005	33,654,324	92,119,560
West Indies:				
Danish West Indies	335,959	513,787		
French West Indies	1,326,232	99,382		
British West Indies	5,539,461	14,579,986		
Dutch West Indies	365,121	90,123		
Hayti	1,955,406	2,948,295	29,941,525	77,947,333
San Domingo	390,845	1,285,873		
Cuba	5,099,954	47,294,203		
Porto Rico	1,327,026	3,672,274		
Total	16.340,004	70,483,923	29,941,525	77,947,333
Grand total	28,405,904	158,283,945	68,104,983	178,692,377

The value of exports to these countries is about three eighths of the value of imports from them. The exchange requires in cash, to settle the difference, more than $110,000,000. Almost four fifths of the great aggregate of imports is for sugar and coffee, the former mainly from the West Indies, the latter mostly from South America.

The total values of the different classes of agricultural exports from the United States to South American countries, for the fiscal year 1889, are as follows:

Countries.	Animals and their products.	Bread and breadstuffs.	Miscellaneous products.	Total agricultural exports.
Argentine Republic	$224,141	$11,491	$68,470	$304,102
Bolivia	2,100	....	....	2,100
Brazil	729,239	4,103,051	71,131	4,903,421
Chili	136,508	201,346	3,909	341,763
Peru	108,411	1,788	2,332	112,531
Colombia	426,950	388,700	168,465	984,115
Uruguay	46,061	283,258	31,093	360,412
Venezuela	691,083	989,589	124,522	1,805,194
Ecuador	207,398	66,269	2,005	275,672
French Guiana	44,687	27,939	10,317	82,943
British Guiana	559,967	594,241	76,943	1,231,151
Dutch Guiana	106,992	58,123	6,645	171,760
South America	3,283,537	6,725,795	565,832	10,575,164

TRANSPORTATION RATES.

There have been published in each monthly crop report during the year statements showing the rates of freight upon our principal products of agriculture, and farmers' supplies, by rail and water, from the important shipping points in all parts of the country to the large market centers; also the cost of transporting our surplus products to foreign countries. It is doubtless understood that these rates were those in operation upon the first day of each month, and did not show the changes occurring between the reports.

For the first five months of the year the rates from Chicago to New York and points taking New York rates, remained the same. The returns for June 1 showed a decrease of 5 cents per 100 pounds upon packing-house products, oats, and live hogs, and an increase of 15 cents upon wool. The application of the 3 cents differential to Boston by the Grand Trunk road, and the Wabash (Canadian Pacific Dispatch Line) claiming the same right, caused another reduction in rates, as shown by the returns July 1. Dressed meats dropped from 45 to 33 cents, wheat and flour from 25 to 22½, and live cattle from 26 to 19½ cents. The rate upon wool was decreased from 65 cents June 1 to 50 cents, the same rate reported January 1. From this cause a further reduction was reported August 1. Packing-house products were reduced from 25 to 23, dressed meats from 33 to 30, cattle from 19½ to 18, and hogs from 25 to 23 cents. The returns for September 1 showed only one change, *i. e.*, wool was reduced from 50 to 34½ cents per 100 pounds.

The following table shows the rates in operation January 1, 1890, upon a few of the more important articles of shipment from Chicago to Boston, New York, Philadelphia, and Baltimore, and the changes reported during the year:

[In cents per 100 pounds.]

Articles (carloads).	From Chicago to—											
	Boston.						New York.					
	Jan. 1.	June 1.	July 1.	Aug. 1.	Sept. 1.	Dec. 1.	Jan. 1.	June 1.	July 1.	Aug. 1.	Sept. 1.	Dec. 1.
Packing-house products	35	30	......	28	......	35	30	25	......	23	......	30
Dressed meats	48	......	33	30	......	45	45	......	33	30	......	45
Flour	30	......	27½	......	......	30	25	......	22½	......	......	25
Wheat, rye, and barley	30	......	27½	......	......	30	25	......	22½	......	......	25
Corn	25	......	......	......	......	27½	20	......	......	......	......	22½
Oats	30	25	......	......	......	30	25	20	......	......	......	25
Cattle	26	......	19½	18	......	26	26	......	19½	18	......	26
Sheep	30	......	......	......	......	......	30	......	......	......	......	......
Hogs	30	25	......	23	......	30	30	25	......	23	......	30
Wool	55	71	55	......	39½	71	50	65	50	......	34½	65

Articles (carloads).	From Chicago to—											
	Philadelphia.						Baltimore.					
	Jan. 1.	June 1.	July 1.	Aug. 1.	Sept. 1.	Dec. 1.	Jan. 1.	June 1.	July 1.	Aug. 1.	Sept. 1.	Dec. 1.
Packing-house products	28	23	......	21	......	28	27	22	......	20	......	27
Dressed meats	43	......	31	28	......	43	42	......	30	27	......	42
Flour	23	......	20½	......	......	23	22	......	19½	......	......	22
Wheat, rye, and barley	23	......	20½	......	......	23	22	......	19½	......	......	22
Corn	18	......	......	......	......	20½	17	......	......	......	......	19½
Oats	23	18	......	......	......	23	22	17	......	......	......	22
Cattle	24	......	17½	16	......	24	23	......	16½	15	......	23
Sheep	28	......	......	......	......	......	27	......	......	......	......	......
Hogs	28	23	......	21	......	28	27	22	......	20	......	27
Wool	48	63	48	......	32½	63	47	62	47	......	31½	62

RATES FROM MISSOURI RIVER POINTS.

The rates from Missouri River points to Chicago and St. Louis were for a portion of the year—from April to September—in a more demoralized condition than they were east of Chicago. Especially was this true of the rates upon packing-house products and cattle. To Chicago from Kansas City, Atchison, St. Joseph, and Omaha the rates upon the former for the five months ending with September 1 were reported at 12 cents per 100 pounds each month, and upon the latter they were from 12½ to 22 cents. June 1 the rates from Kansas City, Atchison, and St. Joseph to Chicago were reported at 12½ cents for cattle and 22½ cents for sheep and hogs, and to St. Louis, 9¼ cents for cattle, 14½ cents for sheep, and 13 cents for hogs, with a rebate of $7.35 per car, regardless of dimensions, to Chicago, and $4.80 to St. Louis.

The following statements are the carload rates, in cents per 100 pounds, as reported upon the first day of each month during the year 1890, from Missouri River points to Chicago and St. Louis:

Months.	To Chicago from—															
	Kansas City, Atchison, and St. Joseph.								Omaha.							
	Packing-house products.	Dressed meats.	Flour.	Wheat.	Other grain.	Cattle.	Sheep.	Hogs.	Packing-house products.	Dressed meats.	Flour.	Wheat.	Other grain.	Cattle.	Sheep.	Hogs.
January 1	18	23½	22½	22½	20	9¼	22	25	18	23½	25	25	20	25	25	25
February 1	18	18½	22½	22½	20	12½	22	25	18	23½	25	25	20	25	25	25
March 1	18	18½	22½	22½	20	12½	22	25	18	23½	25	25	20	25	25	25
April 1	18	18½	22½	22½	20	12½	22	25	18	23½	25	25	20	25	25	25
May 1	12	18½	22½	22½	20	12½	22	25	12	23½	25	25	20	*25	*25	*25
June 1	12	18½	22½	22½	20	*12½	*22	*22	12	18½	25	25	20	21	22	25
July 1	12	18½	22½	22½	20	18	*22	25	12	18½	25	25	20	21	22	25
August 1	12	18½	22½	22½	20	12½	22	22	12	18½	25	25	20	21	22	25
September 1	18	23½	22½	22½	20	22	25	25	18	23½	25	25	20	22	25	25
October 1	18	23½	20	†20	‡17	22	25	25	18	23½	20	†20	‡17	22	25	25
November 1	18	23½	20	†20	‡17	22	25	25	18	23½	20	†20	‡17	22	25	25
December 1	18	23½	20	†20	‡17	22	25	25	18	23½	20	†20	‡17	22	25	25

* Rebate of $7.35 per car, regardless of dimensions. † Wheat, rye, and barley. ‡ Corn and oats.

Months.	To St. Louis from—															
	Kansas City, Atchison, and St. Joseph.								Omaha.							
	Packing-house products.	Dressed meats.	Flour.	Wheat.	Other grain.	Cattle.	Sheep.	Hogs.	Packing-house products.	Dressed meats.	Flour.	Wheat.	Other grain.	Cattle.	Sheep.	Hogs.
January 1	13	18½	17½	17½	15	18	14½	21½	13	18½	20	20	15	16¼	17½	17½
February 1	13	13½	17½	17½	15	13¼	14½	21½	13	18½	20	20	15	16¼	17½	17½
March 1	13	13½	17½	17½	15	7½	14½	21½	13	18½	20	20	15	16¼	17½	17½
April 1	13	13½	17½	17½	15	9¼	14½	21½	13	18½	20	20	15	16¼	17½	17½
May 1	7	13½	17½	17½	15	9¼	14½	21½	7	18½	20	20	15	*16¼	*17½	*17½
June 1	7	13½	17½	17½	15	*9¼	*14½	*13	7	13½	20	20	15	12¼	14½	17½
July 1	7	13½	17½	17½	15	7½	*14½	21½	7	13½	20	20	15	12¼	14½	17½
August 1	12	13½	17½	17½	15	7½	14½	21½	7	13½	20	20	15	12¼	14½	17½
September 1	13	18½	17½	17½	15	18½	21½	21½	13	18½	20	20	15	13¼	17½	17½
October 1	13	18½	15	†15	‡12	13¼	17½	15	13	18½	15	†15	‡12	13¼	17½	17½
November 1	13	18½	15	†15	‡12	18½	21½	21½	13	18½	15	†15	‡12	13¼	17½	17½
December 1	13	18½	15	†15	‡12	13¼	17½	15	13	18½	15	†15	‡12	13¼	17½	17½

* Rebate of $4.80 per car, regardless of dimensions. † Wheat, rye, and barley. ‡ Corn and oats.

REDUCTION IN ALL-RAIL RATES.

A glance at the following table shows what a heavy decrease there has been in the rates of freight upon corn and wheat since 1870. The rates for 1871 to 1873, inclusive, showed an increase over those for 1870, but from that time there has been a steady decline, and this year's average rate upon corn is the lowest ever reported. As compared with the rate for 1870, there is a decrease of nearly 60 per cent. The wheat rate is also the lowest, with the exception of the years 1884 and 1885, when the decrease was 56 per cent for both years as compared with 1870, against 52.1 per cent this year.

The following statement shows the *all-rail* rates in cents per bushel upon corn and wheat from Chicago to New York and upon grain per 100 pounds from St. Louis to New York for the years named:

[Average rate via all rail.]

Years.	Chicago to New York.				St. Louis to New York.	
	Corn per bushel.		Wheat per bushel.		Grain per 100 pounds.	
	Average rate.	Per cent of decrease.	Average rate.	Per cent of decrease.	Average rate.	Per cent of decrease.
	Cents.		*Cents.*		*Cents.*	
1870	28.00	....	30.00	....	....	....
1871	29.68	*6.0	31.80	*6.0	....	....
1872	32.66	*16.6	34.99	*16.6	....	....
1873	28.93	*3.3	31.02	*3.4	....	....
1874	24.50	12.5	26.25	12.5	....	....
1875	22.40	20.0	24.00	20.0	....	....
1876	15.74	43.8	16.86	43.8	39½	....
1877	18.90	32.5	20.50	31.7	41	*3.8
1878	16.52	41.0	17.70	41.0	38	3.8
1879	14.56	48.0	17.74	40.9	33½	15.2
1880	17.48	37.6	19.80	34.0	42	*6.3
1881	13.40	52.1	14.40	52.0	32	19.0
1882	13.50	51.8	14.47	51.8	29½	25.3
1883	15.12	46.0	16.20	46.0	33	16.5
1884	12.32	56.0	13.20	56.0	26	34.2
1885	12.32	56.0	13.20	56.0	22 1/7	43.9
1886	14.00	50.0	15.00	50.0	29	26.6
1887	14.70	47.5	15.75	47.5	32 2/15	18.7
1888	13.54	51.6	14.50	51.7	29½	25.3
1889	12.82	54.2	15.00	50.0	†28½	27.8
1890	‡11.31	59.6	‡14.37	52.1	....	....

* Increase. † Corn 26 cents. ‡ Straight average.

MONTHLY RATES FROM CHICAGO.

To show a comparison of the rates upon some of the more important articles from Chicago to New York, as reported by the several trunk lines upon the first day of each month for a series of years, the following statement is presented:

[In cents per 100 pounds.]

Months.	Cattle, carload.					Sheep, carload.					Hogs, carload.				
	1886.	1887.	1888.	1889.	1890.	1886.	1887.	1888.	1889.	1890.	1886.	1887.	1888.	1889.	1890.
January 1	25	35	35	22½	26	25	45	40	30	30	30	35	30	30	30
February 1	25	35	35	22½	26	25	45	40	30	30	30	35	30	30	30
March 1	35	35	35	22½	26	45	45	40	30	30	30	35	30	30	30
April 1	35	35	35	22½	26	45	45	40	30	30	30	35	30	30	30
May 1	35	35	35	26	26	45	40	40	30	30	30	35	30	30	30
June 1	35	35	25	26	26	45	40	25	30	30	30	35	30	30	25
July 1	35	35	16½	26	19½	45	40	25	30	30	30	30	30	30	25
Jugust 1	35	35	5½	26	18	45	40	25	30	30	30	30	18	30	23
September 1	35	35	10	26	18	45	40	25	30	30	30	30	18	30	23
October 1	35	35	15	26	18	45	40	25	30	30	30	30	18	30	23
November 1	35	35	15	26	18	45	40	25	30	30	30	30	30	30	23
December 1	35	16½	15	26	26	45	19	25	30	30	30	30	25	30	30

Months.	Grain and flour, carload.*					Packing-house products, carload.					Dressed beef, carload.				
	1886.	1887.	1888.	1889.	1890.	1886.	1887.	1888.	1889.	1890.	1886.	1887.	1888.	1889.	1890.
January 1	25	30	27½	25	25	30	35	33	30	30	43½	65	65	50	45
February 1	25	30	27½	25	25	30	35	33	30	30	43½	65	65	50	45
March 1	25	30	27½	25	25	30	35	33	30	30	65	65	65	50	45
April 1	25	30	25	25	25	30	35	30	30	30	65	65	65	50	45
May 1	25	25	25	25	25	30	30	30	30	30	65	65	65	50	45
June 1	25	25	25	25	25	30	30	30	30	25	65	65	65	45	45
July 1	25	25	25	25	22½	30	30	30	30	25	65	65	26½ to 40	45	33
Jugust 1	25	25	25	25	22½	30	30	18	30	23	65	65	7	45	30
September 1	25	25	25	25	22½	30	30	18	30	23	65	65	25	45	30
October 1	25	25	20	25	22½	30	30	18	30	23	65	65	35	45	30
November 1	25	25	20	25	22½	30	30	30	30	23	65	65	35	45	30
December 1	25	25	20	25	25	30	30	25	30	30	65	31	35	45	45

* Not including unground corn after August 1, 1889. From August 1, 1889, to November 1, 1890, the rate on corn was 20 cents per 100 pounds, and December 1, 1890, 22½ cents.

LAKE AND CANAL RATES.

The rates upon corn and wheat via lakes, Chicago to Buffalo, were much lower during 1890 than they were during 1889. In the early part of the season, in fact before navigation was fairly opened, or shippers of ore or other products were ready for business, there was a great demand for loads at the larger ports by the vessel men. This caused a temporary glut of tonnage at Chicago, which reduced rates upon all classes of lake traffic. Oats were carried in May from Chicago to Buffalo as low as 1⅛, corn 1¼, and wheat 1½ cents per bushel. Later in the season, June and July, the rates were somewhat higher, but for the entire season of navigation they were quite low.

Rates via Erie Canal, Buffalo to New York, were also much lower the past season than they were during 1889. Unlike the lake rates, they opened strong, and remained quite steady throughout the season.

Statement showing the weekly range of rates of freight upon corn and wheat, Chicago to New York, via lakes and canal, for the years 1888, 1889, *and* 1890.

[In cents per bushel.]

Week ending—	Lake, Chicago to Buffalo.						Erie Canal, Buffalo to New York.						Chicago to New York, lake and canal.					
	1888.		1889.		1890.		1888.		1889.		1890.		1888.		1889.		1890.	
	Wheat.	Corn.	Wheat.	Corn.	Wheat.	Corn.	Wheat.	Corn.	Wheat.	Corn.	Wheat.	Corn.	Wheat.	Corn.	Wheat.	Corn.	Wheat.	Corn.
May 10	2	1¾	2¼	2	1¾	1½	5	....	4	3⅝	4	3⅝	7	....	6¼	5⅝	5¾	5⅛
17	2	1¾	2¼	2	1¾	1½	3	2¾	4	3⅝	4	3⅝	5	4½	6¼	5⅝	5¾	5⅛
24	2¼	2	2	1¾	1½	1¼	2⅞	2⅝	4	3⅝	4	3⅝	5⅛	4⅝	6	5⅜	5½	4⅞
31	2¼	2	2¼	2	1½	1¼	3¼	3	4	3⅝	3¾	3⅜	5½	5	6¼	5⅝	5¼	4⅝
June 7	....	2	2¼	2	....	....	3¾	3½	4	3⅝	....	....	....	5½	6¼	5⅝	....	....
15	2	1½	2¼	2	....	....	2¾	2½	3¾	3⅜	....	....	4¾	4	6	5⅜	....	....
22	1¾	1½	2	1¾	....	....	2⅛	1⅞	3¾	3⅜	....	....	3⅞	3⅜	5¾	5⅛	....	....
30	2¼	2	2	1¾	....	....	2⅛	2	3¾	3⅜	....	....	4⅜	4	5⅜	5⅛	....	....
July 7	2¼	2	2	1¾	2⅛	2⅛	2¼	2	3¾	3⅜	3⅜	3⅛	4½	4	5¾	5⅛	6⅛	5¼
14	1¾	1½	2¼	2	2¼	2	2½	2¼	2¾	3⅜	3⅝	3⅛	4¼	3¾	6	5⅜	5⅞	5⅛
22	....	2	2¼	2	2¼	2	2¾	2⅛	3¾	3⅜	3⅝	3⅛	....	4½	6	5⅜	5⅞	5⅛
29	....	2¼	2	1¾	2⅛	1⅞	2⅝	2⅜	4	3⅞	3⅝	3⅛	....	4⅝	6	5⅜	5¾	5
Aug. 7	2¾	2½	2¼	2	1½	1¼	3½	3¼	4	3⅝	3¾	3¼	6¼	5¾	6¼	5⅝	5¼	4½
15	3	2¾	2½	2¼	1½	1¼	4¼	4	4	3⅝	4	3½	7¼	6¾	6½	5⅞	5½	4¾
23	3¼	3	2¾	2½	1½	1¼	4⅝	3⅞	4	3⅝	4	3½	7⅝	6⅞	6¾	6⅛	5½	4¾
30	3¼	3	3	2¾	1½	1¼	4⅛	3¾	4½	4	4	3½	7⅜	6¾	7½	6¾	5½	4¾
Sept. 7	3½	3¼	2⅞	2⅝	1¾	1⅜	3⅞	3⅛	4¼	4	4	3½	7⅜	6¾	7⅜	6⅝	5¾	4⅞
15	3¾	3½	2⅞	2⅝	2	1¾	3⅛	3¼	5	4½	3⅞	3⅝	7¼	6¾	7⅞	7⅛	5⅞	5⅛
22	3¾	3½	2⅞	2⅝	2	1¾	4	3⅝	5	4½	3⅞	3⅜	7¾	7⅛	7⅞	7⅛	5⅞	5⅛
29	3¼	13	3	2¾	2	1¾	3¾	3½	5	4½	3⅞	3⅜	7	6½	8	7¼	5⅞	5⅛
Oct. 7	3	2½	3	2¾	2¼	2	3¾	3¼	5	4½	3¾	3¼	6¾	5¾	8	7¼	6	5¼
14	2½	2¼	3	2¾	2⅛	1⅞	3¾	3⅜	5	4½	3¾	3¼	6¼	5⅝	8	7¼	5⅞	5⅛
22	2¼	2	3	2¾	1½	1½	3¾	3¼	5	4½	4¼	3¾	6	5¼	8	7¼	5¾	5
29	2¼	2	3⅛	2⅞	1¾	1½	4	3⅝	5	4½	4¼	3¾	6¼	5⅝	8⅛	7⅞	6	5¼
Nov. 7	2¾	2⅛	3	2½	1¾	1½	4⅛	3¾	5	4½	4¼	3¾	6⅞	5⅞	8	7	6	5¼
15	2¼	2	2	1¾	2	1¾	2¾	2½	5	4⅜	3½	3	5	4½	7	6⅛	5½	4¾
22	2	1¾	2½	2¼	1¾	1½	4¼	3½	5	4⅜	3	2½	6¼	5¼	7½	6⅝	4¾	4
30	....	4	....	....	3½	3¾	....	....	....	....	....	....	....	....	....	....	....	....

TRANSATLANTIC RATES.

Ocean freight rates generally have been much lower than they were for the year 1889. For the first four months of the year, or until about May 1, the rates were considerably higher, but from that time they decreased very rapidly, making the average for the year nearly 30 per cent lower than the average for the previous year. A prominent showing of this is found in the following comparative statement of the rates upon a few of the more important articles of export from

New York to Liverpool, as compiled from the returns from several of the larger steamship companies:

Articles.	January.		February.		March.		April.		May.		June.	
	1889.	1890.	1889.	1890.	1889.	1890.	1889.	1890.	1889.	1890.	1889.	1890.
Wheat, per bushel..	$0.08	$0.11	$0.08½	$0.11	$0.08	$0.10	$0.06	$0.07	$0.05	$0.04	$0.07	$0.04
Corn, per bushel....	.08	.11	.08½	.11	.08	.10	.06	.07	.05	.04	.07	.04
Flour, per barrel...	.60	.72	.60	.72	.60	.72	.48	.60	.36	.36	.48	.36
Bacon, per 2,240 lbs.	6.00	7.80	6.00	8.40	6.00	7.20	4.80	7.20	4.20	3.60	4.20	3.00
Lard, per 2,240 lbs..	6.00	7.80	6.00	8.40	4.80	6.60	4.80	5.40	3.60	3.00	4.20	3.00
Beef, per tierce	1.20	1.44	1.20	1.44	.96	1.32	.72	1.08	.72	.60	.72	.48
Pork, per barrel....	.84	.96	.84	.96	.72	.84	.54	.84	.48	.48	.60	.36
Cotton, per pound..	$.00\frac{7}{16}$	$.00\frac{7}{16}$	.00½	.00½	$.00\frac{3}{8}$	$.00\frac{7}{16}$	$.00\frac{3}{8}$	$.00\frac{5}{16}$	.00¼	$.00\frac{3}{16}$	$.00\frac{7}{32}$	$.00\frac{3}{16}$
Apples, per barrel..	.72	.72	.72	.72	.66	.72	.60	.72	.60	.72	.60	.48
Butter, per 2,240 lbs.	9.60	9.60	9.60	10.80	9.60	9.60	8.40	8.40	7.20	7.20	8.40	7.20

Articles.	July.		August.		September.		October.		November.		December.	
	1889.	1890.	1889.	1890.	1889.	1890.	1889.	1890.	1889.	1890.	1889.	1890.
Wheat, per bushel..	$0.06	$0.05	$0.09	$0.05½	$0.08	$0.03	$0.11	$0.03	$0.11	$0.03	$0.10	$0.06
Corn, per bushel....	.06	.05	.09	.05½	.08	.03	.11	.03	.11	.03	.10	.06
Flour, per barrel..	.50	.36	.60	.36	.72	.24	.72	.24	.72	.36	.72	.48
Bacon, per 2,240 lbs.	4.20	3.60	5.32	3.00	6.60	2.40	7.20	2.40	7.80	2.40	8.40	4.80
Lard, per 2,240 lbs..	4.20	3.60	4.80	3.00	6.00	2.40	7.20	2.40	7.80	2.40	8.40	4.20
Beef, per tierce	.84	.60	.96	.48	1.20	.48	1.32	.48	1.44	.48	1.50	.72
Pork, per barrel....	.60	.48	.72	.36	.72	.36	.96	.25	.96	.36	1.08	.48
Cotton, per pound..	$.00\frac{5}{16}$	$.00\frac{3}{16}$	$.00\frac{3}{8}$	$.00\frac{3}{16}$	.00¾	.00½	$.00\frac{5}{8}$	$.00\frac{5}{16}$	.00½	.00¼	$.00\frac{7}{16}$	.00½
Apples, per barrel..	.60	.60	.72	.72	.72	.60	.72	.60	.72	.48	.72	.48
Butter, per 2,240 lbs.	8.40	8.40	8.40	6.00	9.60	7.20	10.80	7.20	10.80	6.00	10.80	7.20

For comparison and record the following tables, showing the annual average rates upon wheat and the monthly average rates upon grain from New York to Liverpool for a series of years, are presented:

Average cost per bushel for transporting wheat from New York to Liverpool for the years 1866–'90.

Years.	Steamer rates.		Years.	Steamer rates.	
	Pence.	*Cents.*		*Pence.*	*Cents.*
1866	4.74	9.48	1879	6.20	12.40
1867	5.18	10.36	1880	5.88	11.76
1868	7.18	14.36	1881	4.08	8.16
1869	6.40	12.98	1882	3.87	7.74
1870	5.78	11.56	1883	4.54	9.08
1871	8.16	16.32	1884	3.40	6.80
1872	7.64	15.28	1885	3.60	7.20
1873	10.56	21.12	1886	3.46	6.92
1874	9.08	18.16	1887	2.71	5.42
1875	8.07	16.14	1888	2.67	5.34
1876	8.02	16.04	1889	4.06	8.12
1877	6.93	13.86	1890	*2.96	*5.92
1878	7.61	15.22			

* Straight average.

Average monthly price paid per bushel for carrying grain from New York to Liverpool for the years 1886–'90.

Months.	1886.		1887.		1888.		1889.		1890.	
	Pence.	*Cents.*	*Pence.*	*Cents.*	*Pence.*	*Cents.*	*Pence.*	*Cents.*	*Pence.*	*Cents.*
January	3.37	6.75	4.91	9.83	2.41	4.83	4.16	8.33	5.33	10.66
February	2.33	4.66	3.66	7.33	1.83	3.66	4.33	8.67	5.41	10.83
March	2.41	4.83	3.16	6.33	.83	1.66	3.96	7.92	5.00	10.00
April	3.66	7.33	1.50	3.00	.43	.87	2.91	5.83	3.50	7.00
May	3.79	7.58	1.58	3.16	.62	1.25	2.50	5.00	2.00	4.00
June	4.75	9.50	2.12	4.25	1.66	3.33	3.41	6.83	2.00	4.00
July	2.83	5.66	2.62	5.25	1.75	3.50	3.00	6.00	2.33	4.66
August	1.83	3.66	3.00	6.00	2.33	4.66	4.33	8.67	2.66	5.33
September	2.66	5.33	1.83	3.66	5.33	10.66	4.08	8.17	1.50	3.00
October	4.00	8.00	2.00	4.00	4.50	9.00	5.41	10.83	1.50	3.00
November	4.25	8.50	3.50	7.00	4.50	9.00	5.58	11.17	1.29	2.58
December	4.66	9.33	3.00	6.00	5.87	11.75	5.00	10.00	3.00	6.00

REPORT OF THE MICROSCOPIST.

SIR: I have the honor to submit herewith my nineteenth annual report upon the work done in the Division of Microscopy. This work relates largely to the microscopy of foods, food fats, and oils.

A number of lard compounds have been examined and reported on, at the special request of the Agricultural Committee of Congress. I have also investigated a number of samples of various brands of lard and lard compounds for and at the request of the Executive Committee of the National Grange of Virginia. Certain fibers have been investigated for and at the request of the Secretary of the Treasury, and also a different class of fibers for and at the request of the Postmaster-General.

I have brought to completion my invention for testing the tensile strength of textile fibers, and it will be used during the current year.

The miscellaneous work of the Division has varied from the examination of suspected butters from dealers and others to investigation of the material of wrappers of cheap cigars sold at 2 cents apiece, and includes special work as may be required for other Divisions of the Department.

As much interest has been manifested by our correspondents in the United States in relation to my paper on the edible mushrooms of the United States and their cultivation, I have prepared, with the approval of the Assistant Secretary, a more extended paper on this subject, with additional illustrations of both edible and poisonous varieties, including an account of the various European methods of mushroom culture. Specimens of edible and poisonous mushrooms have been received from Alabama, Ohio, Virginia, Maryland, and the District of Columbia.

Samples of pure fish liver oils of many varieties, have been received from Hon. Marshall McDonald, U. S. Commissioner of Fish and Fisheries; of pure native olive oil from Mr. S. S. Goodrich, of the Quito Olive and Vine Farm; of the pure seed oils from the late F. S. Pease, manufacturer of pure oils, Buffalo, New York.

The correspondence of the Division receives careful and prompt attention.

Very respectfully,

THOMAS TAYLOR,
Microscopist.

HON. J. M. RUSK,
Secretary.

THE SILVER TEST FOR ADULTERATIONS OF LARD AND OILS.

HOW TO DETECT FICTITIOUS LARD.

On receiving samples of suspected lards I first heat 2 ounces of each sample in a porcelain evaporating basin over a slow fire until the lard begins to fume, when it is removed and allowed to cool slowly in the same basin in a temperature of about 75° F. If the sample is a composition of stearin and cotton-seed oil it will cool in a few minutes, but if it is pure lard it will require perhaps from three quarters of an hour to an hour to cool. Fats thus treated will yield very fine typical crystals. By means of the microscope, without using chemicals, the crystals of lard may be distinguished from those of oleo, stearin, palmitin, stearic acid, or palmitic acid.

Having obtained satisfactory proof in this direction, I next proceed to my second test, viz, that of the color reactions brought about by treating the samples with a solution of nitrate of silver.

Before making experiments with chemical tests upon "commercial lards" it is obvious that one should be familiar with the results of the same tests upon the individual oils and fats which may enter into their composition. "Commercial lard" is largely made up of stearin and cotton-seed oil. Sometimes there is a trace of pure lard in it, but generally speaking not any. My method of using the nitrate of silver solution in testing commercial lards is based upon experience gained by ascertaining, first, the reactions of the nitrate of silver of various degrees of strength on the pure fats used singly, and secondly, upon combinations of these fats.

How to prepare the silver test.—First, dissolve the nitrate of silver in distilled water to saturation. To 1 fluid ounce of this add 2 fluid ounces of distilled water, and mix well in a perfectly clear stoppered bottle. The test tubes used should be well made, five eighths of an inch in diameter by 6 inches in length. Each tube should be numbered. Into each pour two cubic centimeters of the fat to be tested, made liquid by heat. Secure the contents with a well-fitting cork, and mix quickly while the fat is quite liquid. Remove the cork and heat the silver and fat evenly from end to end of the tube. Bring the silver solution to the boiling point. The vapor of the silver solution retained in the oil should show signs of bursting into steam. Heating and boiling should be accomplished in about one minute and the tube then replaced in the rack to cool.

Oleic acid, marked chemically pure, from Eimer and Ahmend, on being boiled with the silver solution one minute becomes slightly cloudy, as if it contained a solid fat of a light chrome color, and the silver solution becomes highly charged with what appears to be a silver precipitate of a brownish-pink color, whether viewed by transmitted or reflected light. This pinkish colored precipitate of silver has been observed to occur on three occasions with other oils; once with linseed oil, once with poppy seed, and once with peanut oil. I think when it occurs it indicates the presence of free oleic acid. Stearic acid submitted to the same test showed no change of color or precipitate of silver. Palmitic acid gave the same results. Glycerine, a component part of fats, I treated in like manner. Price's glycerine was used, adding a small portion of alcohol simply for the purpose of thinning it, so that if the silver were deoxidized it would readily precipitate. On boiling the solution a silver stain became

apparent at the bottom of the tube. When cool the entire mixture was colored a light slate color, from a slight precipitate of silver.

By direct experiment I find that chemically pure stearin may be boiled in a solution of the nitrate of silver without suffering discoloration, and from the fact that no deposit of metallic silver appears in the silver solution employed it is evident that stearin under this condition does not deoxidize nitrate of silver.

Palmitin, marked chemically pure, treated in the same manner, exhibits properties very much like those of stearin. This fat when cooled presents a pure white color, but I have observed that the silver solution was slightly darkened on boiling. I think probably the sample of palmitin used contained a trace of olein.

Commercial oleo, beef oil, an extract of beef fat, is composed largely of the olein or oil of beef fat. It also contains palmitin, and a very small percentage of stearin. Boiled with the nitrate of silver solution, the *solid fat* of the oil retains its original color, but the *oil proper* causes a slight darkening of the solution.

By these experiments it will appear that neither stearin nor palmitin deoxidizes silver. Should this prove correct, it will appear evident that the pure oil of beef fat decomposes the silver to a very limited extent. If soft commercial stearin, which contains a trace of beef oil proper, is tested in the same way, it will be observed that while the stearin is not affected the beef oil causes a slight precipitation of silver, as in the case of commercial oleo.

Pure and perfectly fresh leaf lard treated as above is not changed in color, neither does it precipitate silver from the diluted solution, but late experiments demonstrate that if pure lard is exposed to the atmosphere of a warm room for several days its chemical properties are somewhat changed, and on testing it with the silver solution not only is the silver solution darkened but the hot lard becomes brown and a dark precipitate of silver is formed.

A sample of the same lard exposed for three days longer, on being tested in the same manner, showed conclusively, on being heated to the boiling point of the silver solution, an increase of brown coloration of the liquid, together with a dark precipitate of silver in the silver solution at the bottom of the tube. On standing for thirty minutes a dark ring of silver precipitate is observed resting on the surface of the silver solution. In connection with these experiments I tested in the same way a sample of pure leaf lard which I had rendered myself in June last. This lard had been continuously exposed to light and air in a temperature of about 75° F. On treating this sample of the lard with the silver solution, silver began to fall quickly in the solution as the temperature increased, until its density had become such that a solid gray mass of silver apparently filled the bottom of the test tube to the depth of half an inch, and the liquid lard had become quite brown in color.

The lard when cold (congealed) has a slight brownish tinge, but on remelting it, it appears quite brown and translucent by reflected light; by transmitted light it appears light brown and translucent.

It will be seen by these experiments with lard and the silver test, that the condition of the lard as regards freshness must be considered, otherwise pure lard that is slightly acid from exposure may be condemned as adulterated, or as being a compound of lard and cotton-seed oil.

In England at the present time, under the silver test, a person may be sent to the penitentiary for selling pure lard, because of the honest

conviction of some experts that lard exhibits no reaction with the silver solution.

SILVER TEST FOR OLIVE OIL.

In the following experiments the olive oil and other oils treated are from sources which I know to be reliable. Samples of our native olive oil were furnished me by Mr. S. S. Goodrich, proprietor of the Quito Olive and Vine Farm, California, and by the Messrs. Wright Brothers, Riverside, California. The seed oils were obtained from the late F. S. Pease, manufacturer of fats and oils, Buffalo, New York.

I found early in my investigation that owing to a difference in the physical properties of the oils, all the spectrum colors might be produced by regulating the strength of the silver solution, subjecting the mixtures to a uniform heat; the color-reactions of certain oils will be observed more quickly than others. Most of the oils when boiled with a saturated solution of the nitrate of silver for one minute will precipitate a portion of silver, some more some less in amount, and in some cases the bright silver is deposited on the wall of the tube opposing the column of oil. But pure olive oil treated with a saturated solution of the nitrate of silver is not as satisfactory in behavior as when a diluted solution is used. I have found that by diluting the saturated solution 50 per cent with distilled water I obtained better results, but that by a still weaker solution the results are still more satisfactory; greater divergence of color and stronger tints are obtained in all the oils.

The solution I have used in these experiments consists of an ounce of the concentrated solution to 2 ounces of distilled water well mixed in a stoppered bottle. With this solution I proceed as follows: Test-tubes five eighths of an inch in diameter and 6 inches in length are arranged in a suitable rack, and numbered from 1 to 7, respectively. No. 1, pure olive oil; No. 2, pure lard oil; No. 3, cotton-seed oil; 4, poppy-seed oil; 5, peanut oil; 6, oil of sesame (benne oil); 7, colza oil. A well-fitting cork is provided for each tube, and a spirit lamp placed conveniently. Into each tube I pour 2 cubic centimeters of the silver solution, following it with 4 cubic centimeters of the oil in the order given above. Each tube is tightly stoppered to prevent staining the fingers and is well shaken, so that the solution will be intimately mixed with the oil. The corks are then removed and the tubes replaced in the rack. At this stage it will be observed that the oils appear to have changed color, becoming more or less cloudy and of different tints or shades of color. This change of color and cloudiness arises from the precipitation of natural fats of the oils, which finally fall and rest on the surface of the silver solution. I then boil each mixture, holding the tube over the flame of the lamp, moving it backwards and forwards until the clear silver solution boils. With an adequate flame the time required for this process should not exceed one minute for each sample. Observe changes of color as they occur.

No. 1. Pure olive oil. Natural color a greenish yellow, with a nutty flavor. The clear silver solution on boiling for one minute exhibits a whitish bloom owing to a slight reduction of silver, but soon clears. If properly heated the oil will change to a well-defined light sienna color, translucent owing to the precipitate of fat, but with no deposit of silver. At this stage of the experiment sometimes, from overheating, a shade of silver may be observed on the tube wall opposing the oil column near the surface of the silver solution. In this case the oil is much darker. This observation is important from what follows on heating the other oils.

No. 2. Pure lard oil. Natural color light straw. The silver solution is slightly darkened on boiling, and a slight deposit of silver falls to the bottom of the test tube. In the course of several days the oil appears lighter in color and translucent, owing to the deposit of fat.

No. 3. Cotton-seed oil (unbleached). Natural color deep yellow. The silver solution is slightly darkened, afterwards clearing. The color of the oil changes to a reddish yellow, and the tube wall on cooling is generally spotted with silver. Rancid lard oil yields more of the silver precipitate than the fresh oil.

No. 4. Poppy-seed oil. Natural color deep yellow. The silver solution becomes reddish brown changing to black. This, later, coagulates and becomes jet-black, rising to the surface of the silver solution. This feature is constant. The oil above is cloudy from the precipitate of natural fat, and changed in color to a greenish yellow, but after standing several days the dark fat precipitates and the oil becomes clear. A very slight deposit of silver is observed at the bottom of the tube, after twenty-four hours.

No. 5. Peanut oil. Natural color light straw. The silver solution is slightly darkened, with a light deposit of silver at the bottom of the tube. Bright specks of silver appear on the tube walls opposing the silver solution. A light orange-colored congealed fat soon deposits on the surface of the silver solution. The oil becomes perfectly clear and of a pale sienna color. After several days the precipitated fat changes in color from orange to bright chrome yellow and a very heavy bright deposit of silver falls to the bottom of the test tube.

No. 6. Oil of sesame (benne). Natural color very light greenish yellow. The silver solution is slightly darkened. Later it clears up colorless. Slight deposit of silver. The oil changes to a light straw-color on precipitation of its fat, which rests on the silver solution.*

No. 7. Colza oil. Natural color light greenish yellow. Heated with the silver solution, colza oil becomes saffron color viewed by transmitted or reflected light; after several days changes to a very dark amber viewed by transmitted light. The silver solution exhibits a slightly yellow color on heating, but clears depositing silver lightly at the bottom of the test-tube. On standing for thirty-six hours silver specks are seen on the tube wall opposing the oil column.

Having acquired a knowledge of the properties of the individual oils, as above, I proceed to combine them respectively and individually with the pure olive oil and silver solution and note results, using the same proportions of each mixed oil with 2 cubic centimeters of the silver solution as in the experiments with the individual oils, observing the same method of treatment:

No. 1. Pure olive oil and pure lard oil, 4 cubic centimeters of each, to which is added 2 cubic centimeters of the silver solution.

No silver is thrown down in the silver solution during the heating process, but after standing several days a very light silver precipitate is frequently observed on the tube wall opposing the oil. Color a light straw, lighter than that of either oil when treated singly.

No. 2. Olive and cotton-seed oil. On boiling olive and cotton-seed oil a very slight dark shade sometimes occurs in the silver solution which clears on cooling. No silver is thrown down to the bottom of the test-tube if the cotton-seed oil is perfectly fresh. On standing several days a narrow band of orange-colored fat appears rest-

---

* Olive and sesame oils may be tested to profit by either the nitric or the sulphuric acid tests given in my last annual report to the Secretary of Agriculture, volume 1889, page 197.

"Test A, 55 parts sulphuric acid chemically pure, combined with 45 parts distilled water, by measure. Specific gravity 1.575, temperature 71.6° F., 22° C.

"Test B, 55 parts sulphuric acid chemically pure, combined with 30 parts distilled water, by measure. Specific gravity 1.648, temperature 71.1° F., 22° C."

If the oil of sesame is present in olive oil, it may be detected by either test A or B. By the former as small an amount as 5 per cent will be indicated. By test B a well-defined violet tinge is seen in the lower layer of the tube, and above this, about midway of the tube, a dark band characteristic of the oil of sesame is observed. The color reactions of the oil of sesame treated with test A are different from the color reactions with test B (see Plate 4, Figs. 3, 4). See also in same report nitric acid test for olive oil, which distinguishes it from all other oils, lard oil excepted.

ing on the silver solution. The oil appears a clear light straw-color by transmitted light, dark brown color by reflected light after the lapse of several days. The tube wall is spotted with the silver deposit.

No. 3. Olive and poppy-seed oil. Light deposit of silver at the bottom of the tube. Light brown deposit of natural fat with particles of the fat light brown in color dusting the wall of the tube. No deposit of silver is observed after standing for several days. Color of the oil, light yellow by reflected light and the same by transmitted light.

No. 4. Olive and peanut oil. A heavier deposit of silver appears in the silver solution, but none is seen in the oil column. The oil appears translucent from precipitation of natural fat and becomes an orange color. After eight days the color changed to a chrome yellow.

No. 5. Olive and sesame oil. A light deposit of silver on the tube wall opposing the oil column, the silver solution is clear. The color of the oil by reflected light is a dark amber, viewed by transmitted light it appears a lighter shade of same color. There is a heavy deposit of natural fat brick-dust-red in color, the lower stratum of which appears a light brown.

No. 6. Olive and colza oil. This mixture when combined before heating appears translucent and a very light straw-color, clearing at the surface of the oil quickly, the fats falling to the bottom of the oil column. On boiling, the oil becomes a deep shade of ochre. No bright silver precipitate is observed at this stage.

In the absence of colored illustrations it is difficult to convey an accurate knowledge of the color-changes herein described. I therefore recommend strongly that duplicates of all experiments be made, as strict uniformity of color can not always be attained, and in duplicating one will soon perceive, owing to slight difference in results, that a sample may have been overheated while another has been underheated.

In a series of experiments made with a variety of oils using the *saturated solution* of nitrate of silver precipitates of silver were obtained in each case. After several weeks' exposure to light, the amount of allotropic silver was found to be much increased. (See plates 7, 8, 9, and 10.)

MUSHROOMS OF THE UNITED STATES.

Since the publication of my first report on the edible mushrooms of the United States, which appeared originally in the annual volume of this Department for the year 1875, there has been a continuous demand for information on this subject, applications for copies of that paper having been received from nearly every State of the Union. My present report contains descriptions and illustrations of eight additional species of edible mushrooms common to the United States, together with simple and improved methods of mushroom culture and some recipes for preparing mushrooms for the table which may be welcome in localities where as yet this savory, nutritious, and abundant comestible has not been utilized. Twelve of the poisonous varieties are also described and their distinguishing characteristics illustrated.

Before selecting mushrooms from field or forest inexperienced persons would do well to consider first carefully the descriptions of the characteristics of edible and poisonous varieties given in the respective plates. The taste and odor of a mushroom is quite significant and it would be well to reject all mushrooms found growing in filthy places. The colors of mushrooms should also be carefully observed. A red-topped mushroom with yellow or tan-colored gills, white or pink stalk, is edible, while a red-topped mushroom with white gills and a white stem, is poisonous. The common puff-ball for table use

EIGHT EDIBLE MUSHROOMS COMMON TO THE UNITED STATES.
SECOND SERIES.

TWELVE POISONOUS MUSHROOMS

should have white flesh, a firm texture, and should be free from insects. The small warty puff-ball is not used; it has a bad odor. Avoid mushrooms which on bruising the gills yield a *white milk; they are all poisonous.*

There is a yellow mushroom known to botanists as *Lactarius deliciosus*, which yields an orange milk when bruised. It is of a bright, golden-yellow color, having an odor that has been compared to that of apricots; is found plentifully in some of the States but is practically unknown to the public. For a further description of it see my first paper, "Twelve Edible Mushrooms of the United States," Plate I, Fig. 1.

A class of mushrooms known as *Boleti* supply many edible species. Select none for table use but such as are found growing. In the edible varieties the flesh remains white when broken, but turns quickly a deep blue if poisonous. The Boleti have pores instead of gills. Avoid any of the Boleti having bright red tops. The edible have generally a shaded brown top; the pores underneath may be green or yellow. For culinary purposes remove the spore tubes and stalks. The outer skin of the top is peeled off, when they may be dried on strings, like cut apples, and kept for use. Although this class is not generally regarded as edible in the United States, "it is sold commonly in all stores where beans, barley, and such food substances are kept on sale in Germany." (Cook.)

EIGHT EDIBLE MUSHROOMS OF THE UNITED STATES.

[Description of Plate I.]

FIG. 1. "Plum" mushroom (*Agaricus prunulus*). Of this species Worthington G. Smith gives the following description: "The pure pink gills running considerably down the ringless stem, and the fresh, fragrant smell of meal, at once distinguish this species from all others. The solid stem and very fleshy top are white or some shade of very pale gray. The flesh is firm, juicy, and full of flavor; and broiled or stewed it is a most delicious morsel." It grows in and near damp woods. Its top will measure from an inch and a half to 6 inches across.

FIG. 2. "Variable" mushroom (*Russula heterophylla*). This species is known by its sweet, nutty taste, and is very common in the woods. Its gills are white, and sometimes branched; flesh, white; stem, solid, white, and ringless; top, firm, variable in color, as its name indicates; the thin, viscid covering of the pileus is commonly subdued green, but at one time approaches greenish yellow or lilac, and at another grey or obscure purple. The top is at first convex, becoming concave. It is excellent baked with salt, pepper, and butter, between two dishes.

FIG. 3. "Scaly" mushroom or "Parasol Agaric" (*Agaricus procerus*). This, which is, according to W. Robinson, the "parasol" agaric, is by some thought superior to the common or "Meadow" mushroom. Robinson says: "Whenever an agaric on a long stalk enlarged at the base presents a dry cuticle more or less scaly a darker colored umbonated top, movable ring, and white gills it must be *Agaricus procerus*, the parasol agaric, and it may be gathered and eaten without fear. When the whitish flesh of this species is bruised it shows a light reddish color." It grows in pastures and woods and is known by its long bulbous spotted stem, by the ring that will slip up and down, by the very scaly top, and the gills far removed from the stalk at its insertion. Diameter of top 5 to 8 inches.

FIG. 4. "Honey-colored" mushroom (*Armillaria mellea*). This very common species is not highly esteemed in some countries where other and better sorts can be had. It is acrid when raw. Pileus fleshy, color pale rufous, more or less shaded with yellow. It grows in tufts on old stumps. Stem elastic, gills pallid and running down the stem.

FIG. 5. *Lepiota cepæstipes*, var. *cretaceus*. This very delicate and beautiful agaric is found on tan and leaves in hot houses. The specimens here delineated I found in one of the hothouses of the Department gardens. Its color is very pure white throughout. Both stem and pileus are covered as seen in the drawing, with small chalky tufts. "This species," says Berkeley "is probably of exotic origin, as it never grows in the open air." It is met with in the hothouses of Europe. (Peck).

FIG. 6. "Horse" mushroom. (*Agaricus arvensis*). This species, found in fields and pastures in the autumn is when young and fresh most desirable eating. The top in good specimens is snowy white. Gills pinkish, turning to brown, ultimately becoming brownish black. It has a big ragged floccose ring and pithy stem inclined to be hollow. As soon as broken or bruised this mushroom turns a brownish yellow. Its flesh is firm and delicious and yields an abundant gravy. Diameter of pileus 6 to 24 inches.

FIG. 7. *Cortinarius cærulescens.* Pileus fleshy, a very beautiful blue color. Gills a pure blue. Stem also blue with margined bulb. A cobweb-like filament frequently extends from the base of the stem to the margin of the pileus. Skin is viscid when moist. Grows on stumps.

FIG. 8. "Oyster" mushroom (*Agaricus ostreatus*). Found on dead tree trunks in the autumn. Top cinereous in color. Gills white, stem eccentric or altogether wanting. It usually grows in masses one above another. Worthington G. Smith says of this species: "A dish of them stewed before a very hot fire has proved as enjoyable and nourishing as half a pound of fresh meat." *A. ostreatus* may be dressed in any of the usual ways, but is better cooked over a slow fire.

MUSHROOM CULTURE.

The French often cultivate mushrooms in cellars as well as in caves. The cellar should be warm and dry, as dark as possible, and exposed to no draughts. Only two species thus far have been successfully cultivated, viz, *Agaricus campestris*, and an allied species, *A. arvensis.* Plates III, IV, and V illustrate several modes of cultivation.

FIG. 1, PLATE III, represents a pyramidal-shaped mushroom bed made on the top of cask bottoms, which should be at least 2 feet 6 inches in diameter. They are built in the shape of an old-fashioned sugar loaf about 3 feet in height; the pieces of spawn placed 1½ inches deep and 16 inches apart.

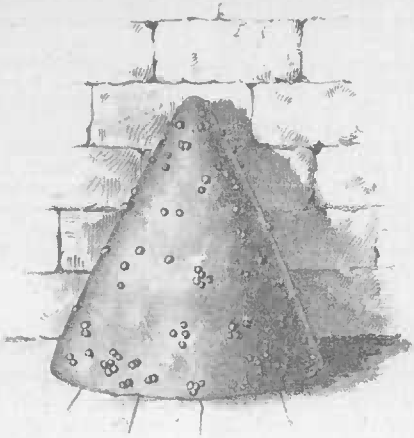
FIG. 2, PLATE III, represents mushroom culture in barrels sawed into two pieces crosswise, each forming a tub. Holes are made in the bottom of each tub and a thin layer of good soil is spread over them inside. They are then filled with good well-prepared stable manure as in the case of ordinary mushroom beds. When the tub is half full with material well pressed down six or seven good pieces of spawn are placed on the surface and the remainder of the tub is piled up with manure well pressed down, the operation being completed by giving to the heap the form of a dome. The boxes or tubs should then be placed in a cellar, thus avoiding the objectionable feature of the steam from the manure.

FIG. 3, PLATE III. Mushroom bed upon a shelf in a stable. Strong bars of iron are driven into the walls, upon which are placed shelves of the proper size covered with earth, upon which is formed a bed that is treated exactly as those made upon the ground. These beds are just as productive as any other kinds.

Mushrooms may be grown in all kinds of greenhouses, "stoves," pits, and frames. Some of the best crops, according to Robinson, have been raised in cold greenhouses, almost too ruinous to grow anything else. Mushrooms may be grown in the open air in gardens. The Paris growers never attempt their culture in summer. The London gardeners very rarely do so. It is in winter that their cultivation is carried on in full vigor in the open air. Abundant crops are grown in the open air by the market gardeners of London and Paris. From their beds mushrooms are gathered in quantities in midwinter as well as in autumn.

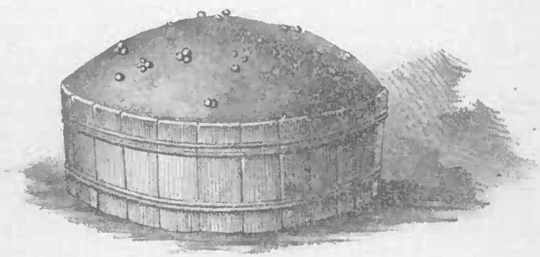
FIG. 4, PLATE IV, represents the uncovered end of a mushroom bed in a Paris market garden. The horse manure is collected for a month or six weeks before the beds are made. All rubbish, chips, etc., are carefully taken out and the heaps are raised generally 2 feet thick and pressed down with the fork. When this is done the bed is well stamped and thoroughly watered and finally stamped again. It is left in this state for eight or ten days, by which time it has begun to ferment, after which the bed should be well turned over and remade on the same place, placing the manure that was at the sides in the center of the heap on turning and remaking. The mass is then left ten days more, at the end of which time the manure is about in proper condition for making the beds that are to bear the mushrooms. Little ridge-shaped beds about 26 inches wide and the same in height are then formed in parallel lines

FIG. 1.



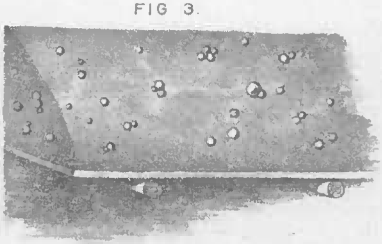
PYRAMIDAL MUSHROOM BED ON FLOOR OF CELLAR.

FIG. 2.



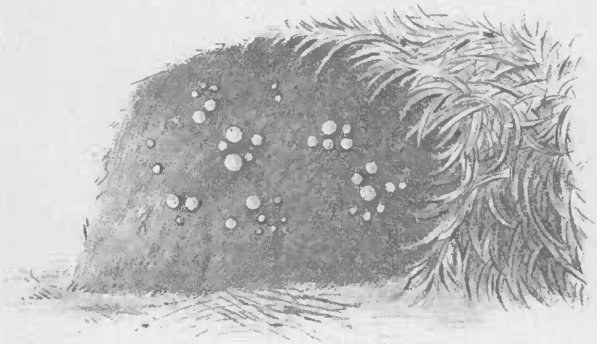
MUSHROOMS GROWN IN BOTTOM OF OLD CASK.

FIG. 3.



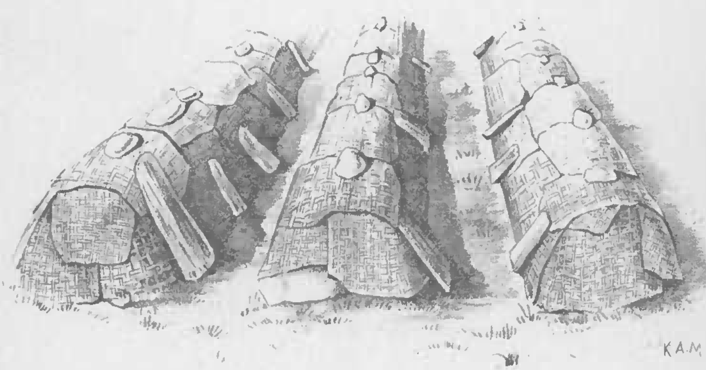
MUSHROOM BED ON RUDE SHELF AGAINST WALL OF CELLAR.

FIG 4



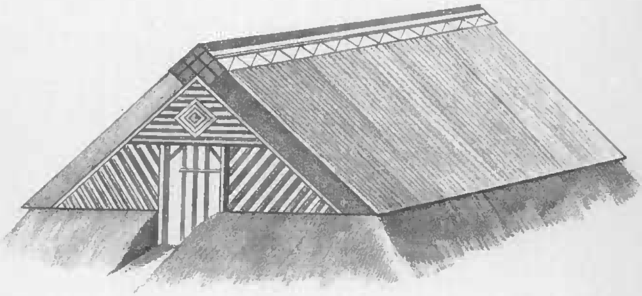
UNCOVERED END OF MUSHROOM-BED IN PARIS MARKET-GARDEN

FIG 5



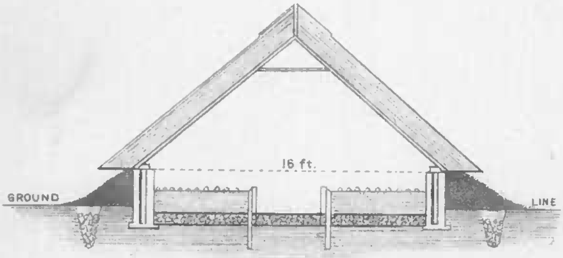
MUSHROOM-BEDS IN MARKET-GARDENS, KENSINGTON, ENGLAND

FIG. 6



VIEW OF UNHEATED MUSHROOM-HOUSE.

FIG. 7.



SECTION OF PRECEDING FIGURE.

at a distance of 20 inches apart and of any desired length. (See Fig. 5, Plate 4.) The beds once made of a firm close-fitting texture, the manure soon begins to warm again, but does not become unwholesomely hot for the spread of the spawn. The spawn is inserted generally within a few inches of the base, about 13 inches apart in the line of course, having ascertained beforehand that the heat is genial and suitable. The pieces of spawn used are about the size of three fingers and then the manure is closed over and pressed firmly around. This done the beds are covered with about 6 inches of clear litter. If after the lapse of ten or twelve days the white filaments are seen spreading in the bed the cultivator knows that the spawn is good; if not, the spawn is rotting and must be removed and replaced with better. When the spawn is seen spreading well through the beds, the bed should be covered with fresh, sweet, rich soil of the garden and applied equally and firmly with a shovel to the depth of about an inch or so. A covering of abundance of litter or old mats is put on after the beds are earthed, and kept in place by means of tiles, bricks, old boards, or any such material for protection. The beds will soon be in full bearing and it is thought better to examine and gather from them every second day or even every day if there are many beds. Occasional watering is necessary in a dry season. The beds are spawned at a temperature of about 80° F.

FIGS. 6 and 7, PLATE V, represents a mushroom house and sections designed with a view to growing mushrooms during the greater part of the year without the aid of artificial heat. It is constructed, as will be seen, in such a way as not to be affected by changes of the external temperature. The walls are hollow and banked round with the soil excavated from the interior. The roof is thatched with reeds and the ends stud-work, lined inside with boards and outside with split larch poles, the cavity to be filled with sawdust or cut straw; a small diamond-shaped ventilator, hung on pivots, to be fixed in each end. The floor may be of concrete or burnt clay, well rammed, and the beds are retained in their places by boards nailed to good oak posts. Care should be taken to put efficient drains so that no stagnant damp may exist about the building.

As the Department of Agriculture has had frequent inquiries as to mushroom spawn and how and where to obtain it, the following, taken from Robinson on Mushroom Culture, is inserted for the benefit of those whom it may concern:

Generally, the spawn is supposed to be analogous to *seed*. It is really what may be termed the vegetation of the plant, or something analogous to roots, stems, and leaves of ordinary plants, the stem, head, and gills of the mushroom being in fact the fructification. Spawn is found in a natural state in half decomposed manure heaps, in places where horse droppings have accumulated and been kept dry, and rarely or never in very moist or saturated materials. This natural spawn is the best, and should be used wherever it can be found. Divide the white spawn into pieces a few inches square, say, an inch or more thick. They will, of course, break up irregularly, but all should be used, whether of the size of a bean or nearly that of the open hand. In most places where horses are kept opportunities of finding this spawn occur. Its white, filamentous, and downy threads have the odor of mushrooms, and the spawn is therefore very easily recognized. It need not be used when found, but may be dried and kept in a dry place for years; has been known to keep as long as fourteen years. To preserve spawn found in a natural state nothing more is required than to take up carefully the parts of the manure in which it is found, not breaking them up more than may be necessary, and placing the pieces, of all sizes, loosely in rough shallow hampers. Place these in some airy loft or shed till thoroughly dry, and afterwards pack in rough boxes till wanted for use.

ARTIFICIAL MUSHROOM SPAWN.

This spawn is made from horse droppings and some cow dung and road scrapings beaten up into a mortar-like consistency in a shed and then formed into bricks slightly differing in shape with different makers but usually thinner and wider than common building bricks. The following proportions are about the best: (1) Horse droppings the chief part; one fourth cow dung; remainder loam. (2) Fresh horse droppings mixed with short litter for the greater part; cow dung one third; and the rest mold or loam. (3) Horse dung, cow dung, and loam in equal parts. These bricks are placed

in some dry airy place and when half dry a little bit of spawn about as big as a hazel nut is placed in the centre of each, or sometimes when the bricks are as wide as long a particle is put near each corner just inserted below the surface and plastered over with the material of the brick. When nearly dry the bricks are placed in a hotbed about a foot thick in a shed or dry place. The bricks are piled openly and loosely and covered with litter so that the heat may circulate evenly among them, not above 60° F. If the temperature should exceed this it may be reduced by removing the covering of the litter. The bricks are frequently examined during the process and when the spawn has been found to spread throughout the brick like a fine white mold it is removed and allowed to dry for future use in a dark place. If allowed to go further than the fine white mold stage and form threads and tubercles in the bricks it has attained a higher degree of development than is consistent with preserving its vegetative powers, and therefore it should be removed from the drying bed in the fine mold stage.

French mushroom spawn differs from our own in not being in the form of bricks or solid lumps, but in rather light masses, scarcely half decomposed, comparatively loose, dry litter. This spawn is obtained by preparing a little bed, as if for mushrooms, in the ordinary way, and spawning it with morsels of virgin spawn, if obtainable. When the spawn has spread through it the bed is broken up and used for spawning beds in the caves or dried and preserved for sale. It is sold in small boxes, and is fit for insertion when pulled in rather thin pieces about half the size of the open hand. In separating it, it divides into many small pieces, every particle of which should be used. The small particles should be strewn broadcast over the bed after the larger pieces have been inserted. There is no necessity for purchasing artificial spawn at all where mushrooms are regularly grown. Nor is there in any case, except at the commencement or to guard against one's own spawn proving bad. To secure good spawn we have only to do as the French growers do, take a portion of a bed where it is thoroughly permeated by the spawn and before it begins to bear and preserve it for future use.

The following methods of cooking mushrooms may prove useful:

Broiled Procerus.—Remove the scales and stalks from the agarics and boil lightly over a clear fire on both sides for a few minutes; arrange them on a dish over freshly made well buttered toast; sprinkle with pepper and salt and put a small piece of butter on each; set before a brisk fire to melt the butter, and serve up quickly. Bacon toasted over broiled mushrooms improves the flavor and saves the butter.

Agarics delicately stewed.—Remove the stalks and scales from young, half-grown agarics and throw each one as you do so into a basin of fresh water slightly acidulated with the juice of a lemon or a little good vinegar. When all are prepared remove them from the water and put them in a stewpan with a very small piece of fresh butter. Sprinkle white pepper and salt and add a little lemon juice; cover up closely and stew for half an hour; then add a spoonful of flour with sufficient cream, or cream and milk, till the whole has the thickness of cream. Season to taste and stew again until the agarics are perfectly tender. Remove all the butter from the surface and serve in a hot dish garnished with slices of lemon. A little mace or nutmeg or catsup may be added, but some think that spice spoils the flavor.

Cottager's Procerus pie.—Cut fresh agarics in small pieces and cover the bottom of a pie dish. Pepper, salt, and place them on small shreds of fresh bacon, then put in a layer of mashed potatoes, and so fill the dish layer by layer with a cover of mashed potatoes for the crust. Bake well for half an hour and brown before a quick fire.

A la Provençale.—Steep for two hours in some salt, pepper, and a little garlic, then toss them in a small stewpan over a brisk fire with parsley chopped and a little lemon juice. (Dr. Badham.)

Agaric ketchup.—Place agarics of as large a size as you can procure, but which are not worm-eaten, layer by layer in a deep pan, sprinkling each layer as it is put in with a little salt. Then next day stir them well several times so as to mash and extract their juice. On the third day strain off the liquor, measure, and boil for ten minutes, and then to every pint of liquor add half an ounce of black pepper, a quarter of an ounce of bruised ginger root, a blade of mace, a clove or two, and a teaspoonful of mustard seed. Boil again for half an hour; put in two or three bay leaves and set aside till quite cold. Pass through a strainer, and bottle; cork well and dip the ends in resin. A very little Chili vinegar is an improvement, and some add a glass of port wine or a glass of strong ale to every bottle. Care should be taken that the spice is not so abundant as to overpower the true flavor of the agaric. A careful cook will keep back a little of the simple boiled liquor to guard against this danger; a good one will always avoid it.

To stew mushrooms.—Trim and rub clean half a pint of large button mushrooms. Put into a stewpan 2 ounces of butter; shake it over a fire until thoroughly melted; put in the mushrooms, a teaspoonful of salt, half as much pepper, and a blade of mace pounded; stew till the mushrooms are tender, then serve on a hot dish. This is usually a breakfast dish.

Mushrooms a la creme.—Trim and rub half a pint of button mushrooms; dissolve 2 ounces of butter rolled in flour in a stewpan; put in the mushrooms, a bunch of parsley, a teaspoonful of salt, half a teaspoonful each of white pepper and of powdered sugar, shake the pan for ten minutes, then beat up the yolks of two eggs with two tablespoonfuls of cream, and add by degrees to the mushrooms; in two or three minutes you can serve them in sauce.

Mushrooms on toast.—Put a pint of mushrooms into a stewpan with 2 ounces of butter rolled in flour; add a teaspoonful of salt, half a teaspoonful of white pepper, a blade of powdered mace, and half a teaspoonful of grated lemon; stew till the butter is all absorbed; then serve on toast, or as soon as the mushrooms are tender.

To pot mushrooms.—The small open mushrooms suit best for potting. Trim and rub them; put into a stew pan a quart of mushrooms, 3 ounces of butter, two teaspoonfuls of salt, and half a teaspoonful of Cayenne and mace mixed, and stew for ten or fifteen minutes or till the mushrooms are tender; take them carefully out and drain them perfectly on a sloping dish, and when cold press them into small pots and pour clarified butter over them, in which state they will keep for a week or two. Writing paper over the butter, and over that melted suet will effectually preserve them for weeks if in a dry, cool place.

To pickle mushrooms.—Select a number of small sound pasture mushrooms as nearly alike in size as possible. Throw them for a few minutes into cold water, then drain them, cut off the stalks and gently rub off the outer skin with a moist flannel dipped in salt;

then boil the vinegar, adding to each quart 2 ounces of salt, half a nutmeg grated, a drachm of mace, and an ounce of white peppercorns. Put the mushrooms into the vinegar for ten minutes over the fire, then pour the whole into small jars, taking care that the spices are equally divided; let them stand a day; then cover them.

Baked mushrooms.—Peel the tops of twenty mushrooms; cut off a portion of the stalks and wipe them carefully with a piece of flannel dipped in salt. Lay the mushrooms in a tin dish, put a small piece of butter on the top of each, and season with pepper and salt. Set the dish in the oven and bake them from twenty minutes to half an hour. When done arrange them high in the center of a very hot dish, pour the sauce round them, and serve quickly and as hot as you possibly can.

Mushrooms with bacon.—Take some full-grown mushrooms and having cleaned them procure a few rashers of nice streaky bacon and fry it in the usual manner. When nearly done add a dozen or so of mushrooms and fry them slowly until they are cooked. In this process they will absorb all the fat of the bacon, and with the addition of a little salt and pepper will form a most appetizing breakfast relish.

Mushrooms en ragout.—Put into a stew pan a little "stock," a small quantity of vinegar, parsley, and green onions chopped up, salt and spices. When this is about to boil, the mushrooms being cleaned, put them in. When done remove them from the fire and thicken with yolks of eggs.

Extract from the letter of a correspondent in Virginia:

* * * I learned so much from your "Twelve Edible Mushrooms" that I wish to express my gratitude for the book and for the clear and distinct instructions you have put in it. I brought my little book down here this fall where people knew of only one edible mushroom. By your aid we discovered others, especially the Giant Puff-ball, which we gathered in great quantities and prepared in more than one fashion for the table, making an excellent addition to the somewhat limited bill of fare found in a country district, If you can spare a few more copies of your pamphlet I should like to give them to some of my friends to whom I think they would prove eminently useful.

TWELVE POISONOUS MUSHROOMS.

[Description of Plate II.]

FIG. 1. "Red-juice" Mushroom (*Hygrophorus conicus*). This species is common in pastures and roadsides. It has a strong and unpleasant odor; flesh, juicy; color of the top, crimson or a deep orange; taste, bitter; stem, hollow. It is found in groups on old tree stumps.

FIG. 2. "Emetic" Mushroom (*Russula emetica*). This dangerous species has a bright scarlet or rose-colored top, sometimes shaded with purple. The skin is readily peeled off exposing the flesh which is white. It is very acrid to the taste.

FIG. 3. "Verdigris" Mushroom (*Agaricus æruginosus*). Pileus fleshy, convexo-plane, covered with green mucus; stem, hollow and scaly, tinged with blue; gills, brown tinged with purple. This mushroom quickly decays. Top is about 3 inches across.

FIG. 4. "Satanical" tube Mushroom (*Boletus satanas*). By far the most splendid of all the Boleti. Top nearly white, very fleshy and a little viscid. Stem firm, exquisitely reticulated. The under surface of the pileus is bright crimson. When bruised or broken the inner fleshy substance becomes a deep blue. As its name indicates this belongs to the class of tube or pore-bearing fungi. The pores are upon the under surface of the pileus and take the place of the gills or lamellæ of the Agaricini group.

FIG. 5. "Trellised" Clathrus (*Clathrus cancellatus*). This is a poisonous mushroom of great beauty and variety. The fœtor exhaled from it is most repulsive. In the young plant, however, the bad odor is not so strong, or may be altogether wanting.

FIG. 6. "Spring" Mushroom (*Agaricus* (*Amanita*) *vernus*). This agaric is found in

the woods in the spring, and is white in all its parts. It is supposed to be very poisonous.

FIG. 7. "Fiery" tube Mushroom (*Boletus piperatus*). One of the smaller Boleti. Taste, highly acrid; grows in woods; it is probably dangerous; never attains a large size.

FIG. 8. "Fly" Mushroom (*Agaricus* (*Amanita*) *muscarius*). This species, allied to the perfectly wholesome red-fleshed mushroom, *Amanita rubescens*, is a bright yellow just beneath the skin, the rest is white. It is usually a bright scarlet on top, sometimes a deep yellow or orange. Few species can exceed it in beauty. It grows in some places in such profusion as to make the very ground scarlet. Found in birch and pine woods.

FIG. 9. "Ruddy-Milk" Mushroom (*Lactarius rufus*). Pileus fleshy, umbonate, at length funnel shaped, dry, zoneless, dark rufous; stem stuffed, rufous; gills crowded, ocherous and rufous. On bruising the gills a white milk exudes which is extremely acrid and corrosive, a distinguishing mark.

FIG. 10. "Fiery Milk" Mushroom (*Lactarius piperatus*). So called from the powerfully acrid milk which it contains, white and abundant. When the milk is placed on the lips or tongue it produces the sensation of scalding or searing with a hot iron. Color white, inclining to cream; flesh firm and solid. Found in dry woods.

FIG. 11. "Bitter" Tube Mushroom (*Boletus felleus*). This mushroom is rare. Pileus is soft, smooth, brown, inclining to reddish grey; stem solid above, attenuated, reticulated; tubes or pores angular, flesh color, as well as the fleshy substance of the pileus when broken. The flesh is very bitter.

FIG. 12. "Fetid Wood-Witch" (*Phallus impudicus*). Had not this species been known to have been eaten it would be hardly necessary to have referred to it. Flies appear to relish it and devour it greedily. It is offensive and dangerous.

BUTTER AND FATS.

ORIGINAL MICROSCOPIC INVESTIGATIONS.

In my early microscopic observations relating to butter and other fats I recommended that, in order to procure highly crystallized fats suitable for microscopic test objects, each fat should be heated to a temperature of 212° F., for one minute, strained to remove tissue, etc., and allowed to cool slowly.

I now find that the fat should be heated, say over the flame of a spirit lamp in a porcelain basin, until it begins to fume, no more, no less, and allowed to cool slowly in the same vessel in which it is melted. Not less than 2 ounces of fat should be melted for each experiment. Hard fats, such as beef fat, in order to obtain well defined crystallization, should be treated as follows: Melt in a porcelain basin 2 ounces of pure fresh beef fat free from tissue, heat to the fuming point; remove from the flame at once, allow it to cool slowly until it becomes semisolid; at this juncture add to it 1 ounce of sweet oil and mix; then allow it to cool slowly in a temperature of about 75° F.

If this process is strictly followed larger and better defined groups of crystals common to beef fat will be obtained than are produced by my original method.

PLATE VI represents the general characteristics of the crystalline groupings of "butter and fats" when subjected to the above treatment. For the sake of convenience the different figures are separated by lines defining small squares on the plate.

FIG. 1. Pure lard crystals viewed by plain light. Their arrangement is that of an aggregation of needle-like crystals proceeding from a common center.

FIG. 2. The same viewed with polarized light, sometimes faintly showing a black cross.

FIG. 3. Oleo crystals viewed by plain light. These are aggregations of branched crystals, color faint, requiring high powers, say × 500, to discern their delicate tracery, which closely resembles the crystalline arrangement of butter by plain light.

FIG. 4. The same object viewed by polarized light. The branchings are not as visible and the black cross is reflected. Such groupings average about .003 of an inch in diameter.

FIG. 5. A group of stearin crystals embedded in palmitin, as seen by polarized light. This fairly represents the crystalline arrangement of commercial stearin. The crystals of stearin appear vividly white under polarized light.

FIG. 6 represents the same group of crystals by plain light.

FIG. 7 represents a mixture of lard and stearin—50 per cent of each—by plain light.

FIG. 8. The same compound by polarized light.

FIG. 9 represents a compound of oleo and stearin—50 per cent of each—by plain light.

FIG. 10. Oleo and stearin by polarized light. The large, central, well-defined branchings represent the stearin. They appear very brilliant in contrast with the translucent mass of palmitin in which they are embedded. In this case the black cross is always wanting. The small globose bodies at the right-hand lower corner of the field are the usual forms of oleo crystallization viewed by polarized light.

FIG. 11. Compound of stearin and butter—50 per cent of each—by plain light. The central figure represents the stearin poorly.

FIG. 12. The same by polarized light. In this case the branchings of the stearin are very readily observed by polar zed light, even with low powers. The stearin largely occupies the field, embedded in the palmitin. In the lower right-hand corner a small mass of crystallized butter is represented which has crystallized apart from the stearin.

FIG. 13. Compound of lard and butter. This combination consists mostly of palmitin, the principal fat of lard, and exhibits delicately branched crystals common to butter, viewed by plain light.

FIG. 14. Same compound viewed by polarized light. A faint black cross is observed. Frequently in such cases a bright rosette-like crystal, or rather aggregation of crystals, is seen, which I consider consists of stearin. With regard to the crystallization of stearin, so as to obtain uniform results, nothing is more simple. I have experimented with the stearin of lard, cotton-seed oil, beef and mutton tallow. The stearine crystal under the microscope with polarized light has distinctive characteristics, whether seen as mere specks or as branching forms. Its brilliancy exceeds that of all other fats under polarized light.

FIG. 15. Butter crystals by plain light.

FIG. 16. Butter crystals by polarized light.

FIG. 17. Butter crystals showing the rosette-like form in center, which I consider represents the natural stearin of butter which has crystallized apart from the palmitin of the butter.

FIG. 18 represents a crystallization of butter which I have frequently met with in butter that has been exposed previously to high atmospheric temperatures; but if such a sample is again heated to the fuming point, as already described, then slowly cooled, and viewed with polarized light the globose forms will again appear as in Fig. 16, changing in several days to those of Fig. 17, and again changing to those represented by Fig. 18. Ultimately they take the forms represented in Figs. 22, 23, 24, 25, 26, 27, 28, 29, and 30.

FIG. 19. Butter and its stearin represented. Stearin of pure butter is obtained by compression, as follows: Place, say, 2 ounces of pure, fresh butter upon several sheets of thick bibulous paper. After several days, most of the oil will be absorbed, remove the butter with a pall t knife and press it between several folds of absorbent paper by means of a common letter press, thus removing the remaining oil and some of the palmitin. Place the solid mass thus obtained in a porcelain capsule over the flame of a spirit lamp and bring it to the fuming point. Then remove it from the fire and strain out the casein, adding, when cooled to a semifluid condition, about one third of its weight in sweet oil. When quite cool examine a portion under the microscope with polarized light, using powers of × 100, turning the polarizer so as to have a dark background, when the crystallized form of stearin will be observed as shown by Fig. 19; the stearin in this case has relatively increased from loss of palmitin and its natural oil in the process of compression and absorption.

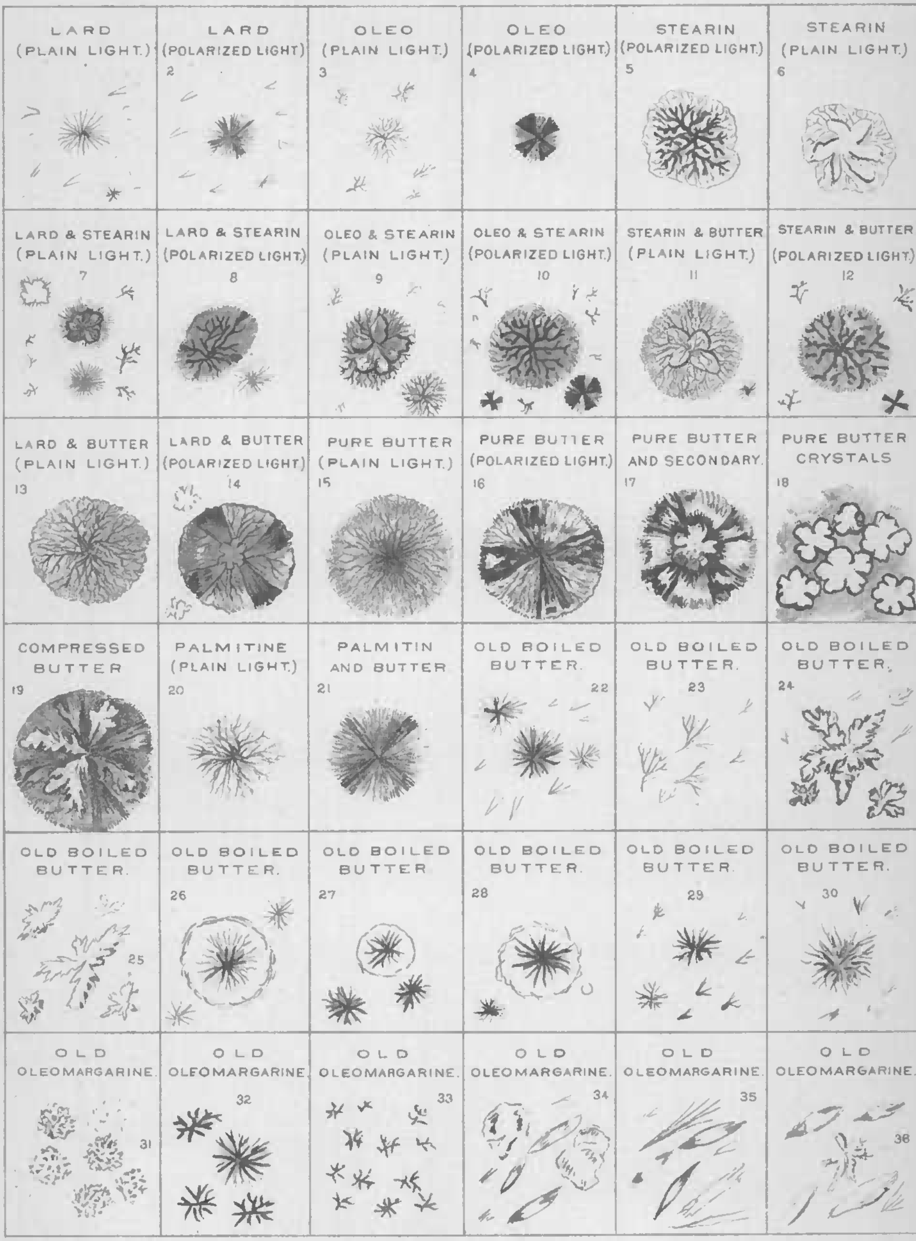
FIG. 20. Palmitin—viewed by plain light, × 500.

FIG. 21. Palmitin and butter.

FIGS. 31, 32, 33, 34, 35, and 36 represent varied views of old oleomargarine.

Having described the microscopical characteristics of these commercial fats, any microscopist by the aid of Plate VI may soon become able to distinguish pure fat from that which has been adulterated.

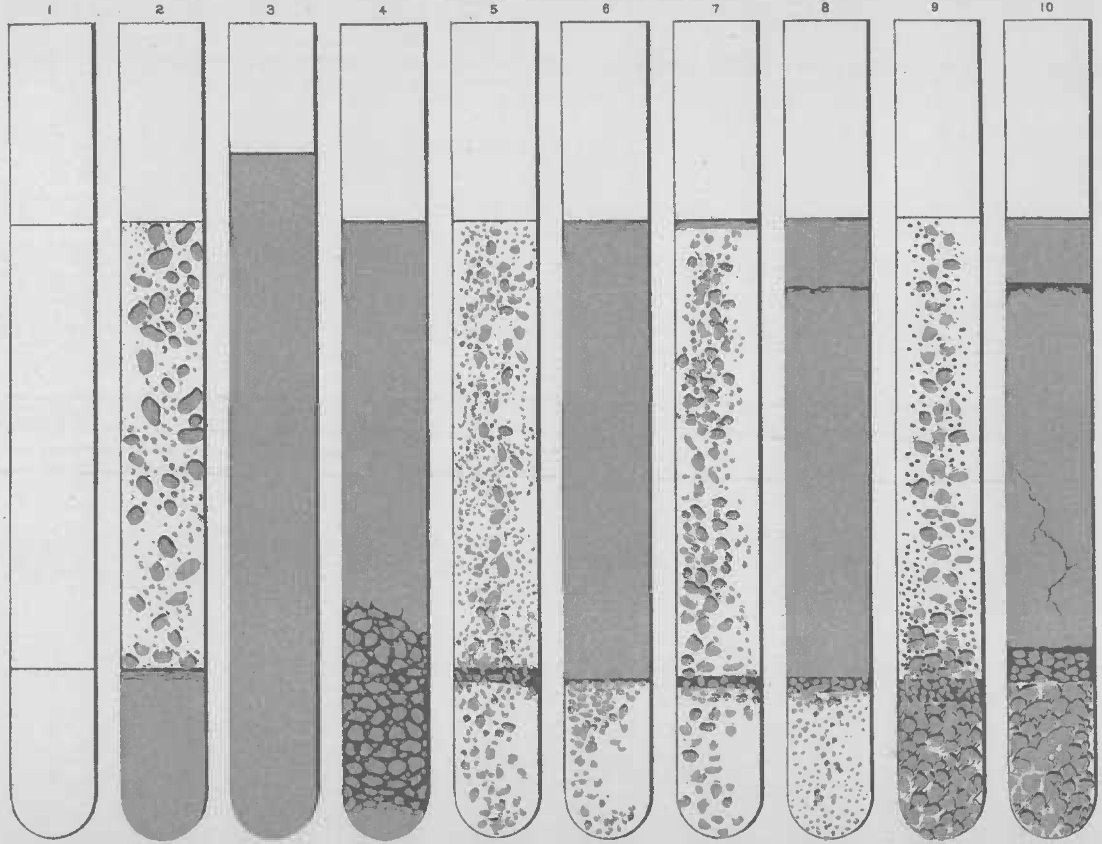
ORIGINAL MICROSCOPIC RESEARCHES
IN FOOD FATS, WITH SPECIAL REFERENCE TO LARD AND OLEO COMPOUNDS,
SUGGESTED BY RECENT DISCLOSURES IN LARD ADULTERATION.



THOS. TAYLOR DEL. Steiner Lith. Co. Roch. N.Y.

NITRATE OF SILVER TEST OF FOOD AND MEDICINAL OILS.

WITH AND WITHOUT PHENOL.



1. TURPENTINE AND NITRATE OF SILVER.
2. EUCALYPTUS OIL AND NITRATE OF SILVER.
3. PHENOL AND NITRATE OF SILVER.
4. OLIVE OIL PHENOL AND SILVER.
5. COD LIVER OIL AND NITRATE OF SILVER.
6. COD LIVER OIL, PHENOL AND SILVER.
7. POLLOCK LIVER OIL AND SILVER.
8. POLLOCK OIL, PHENOL AND SILVER.
9. HAKE LIVER OIL, AND NITRATE OF SILVER.
10. HAKE OIL PHENOL AND SILVER.

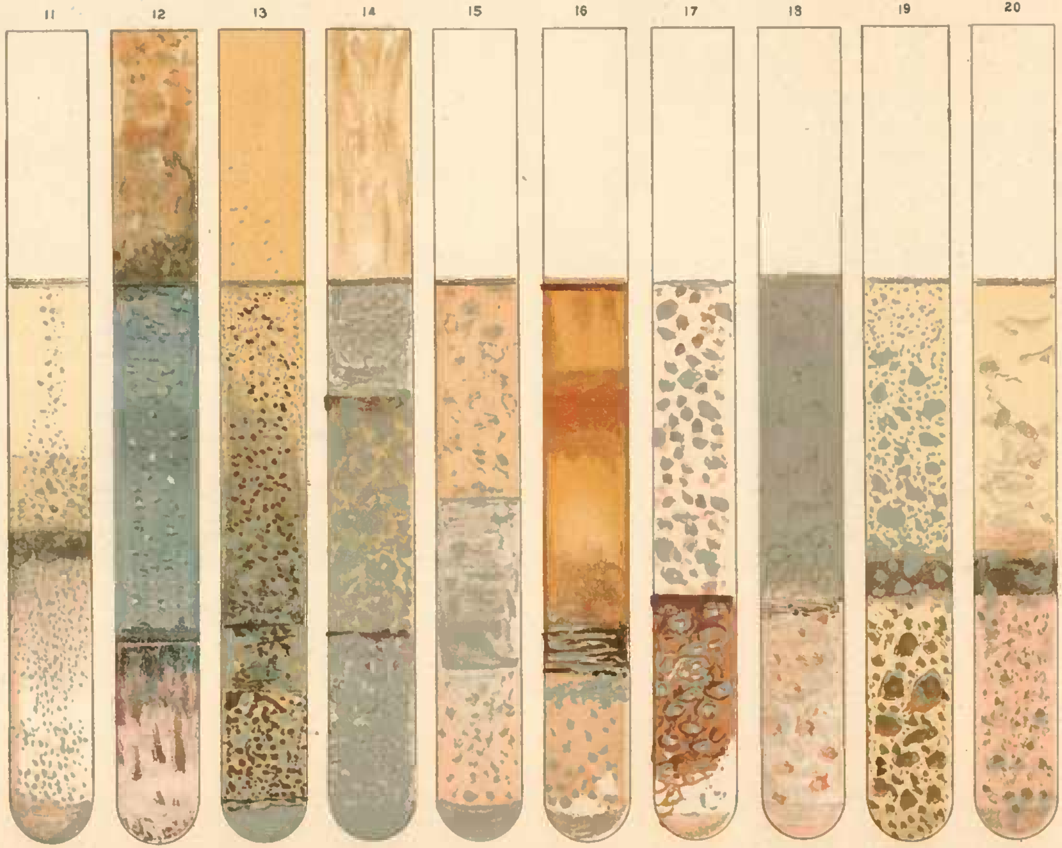
PLATE 7.

Sleeper Lith Co. N.Y.

Sackett & Wilhelms Litho. Co. N.Y.

NITRATE OF SILVER TEST OF FOOD AND MEDICINAL OILS.

WITH AND WITHOUT PHENOL.

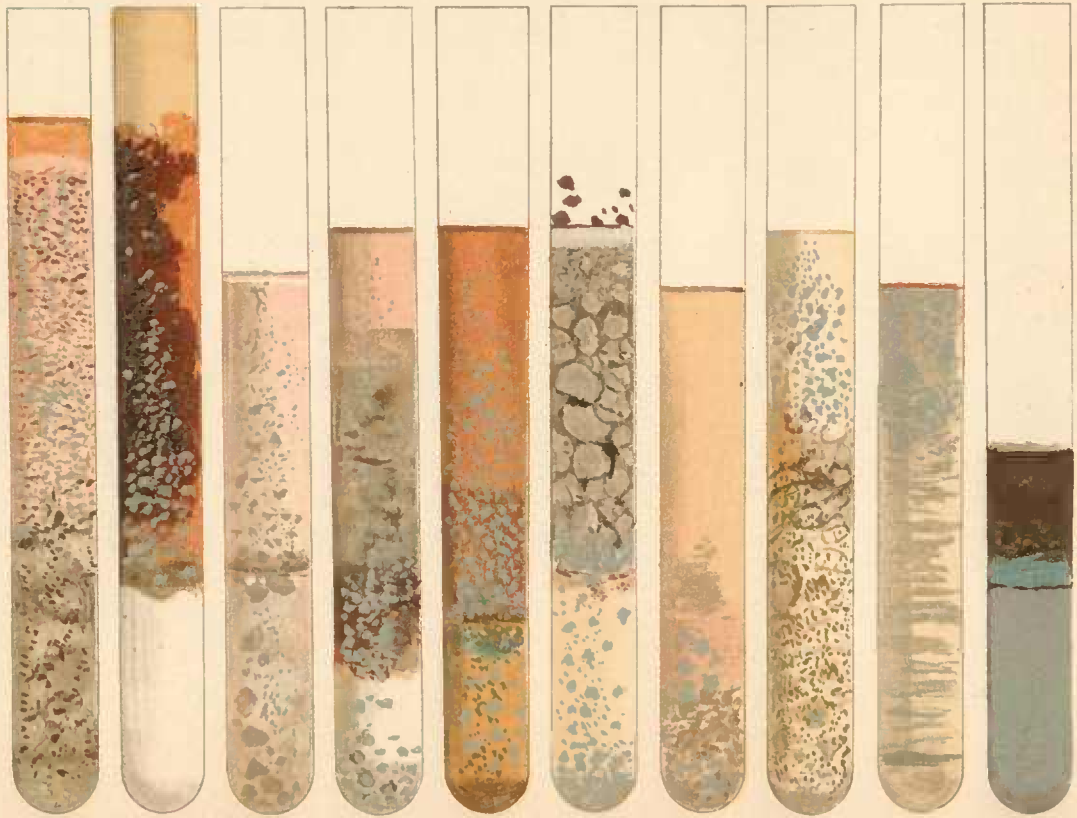


11	12	13	14	15	16	17	18	19	20
LUCCA OLIVE OIL AND NITRATE OF	LINSEED OF PHENOL AND NITRATE OF	TURTLE OIL AND WEAK PHENOL	COTTON SEED OIL PHENOL AND NITRATE	RAZZO (OLIVE OIL) AND NITRATE	MISSION-1 (OLIVE OIL) AND NITRATE	MISSION-2 (OLIVE OIL) AND NITRATE	COTTON SEED OIL PHENOL AND NITRATE	SESAME OIL AND NITRATE OF	CORREGGIOLO (OLIVE OIL) AND PHENOL NITRATE

PLATE 8.

NITRATE OF SILVER TEST OF FOOD AND MEDICINAL OILS.

WITH AND WITHOUT PHENOL.

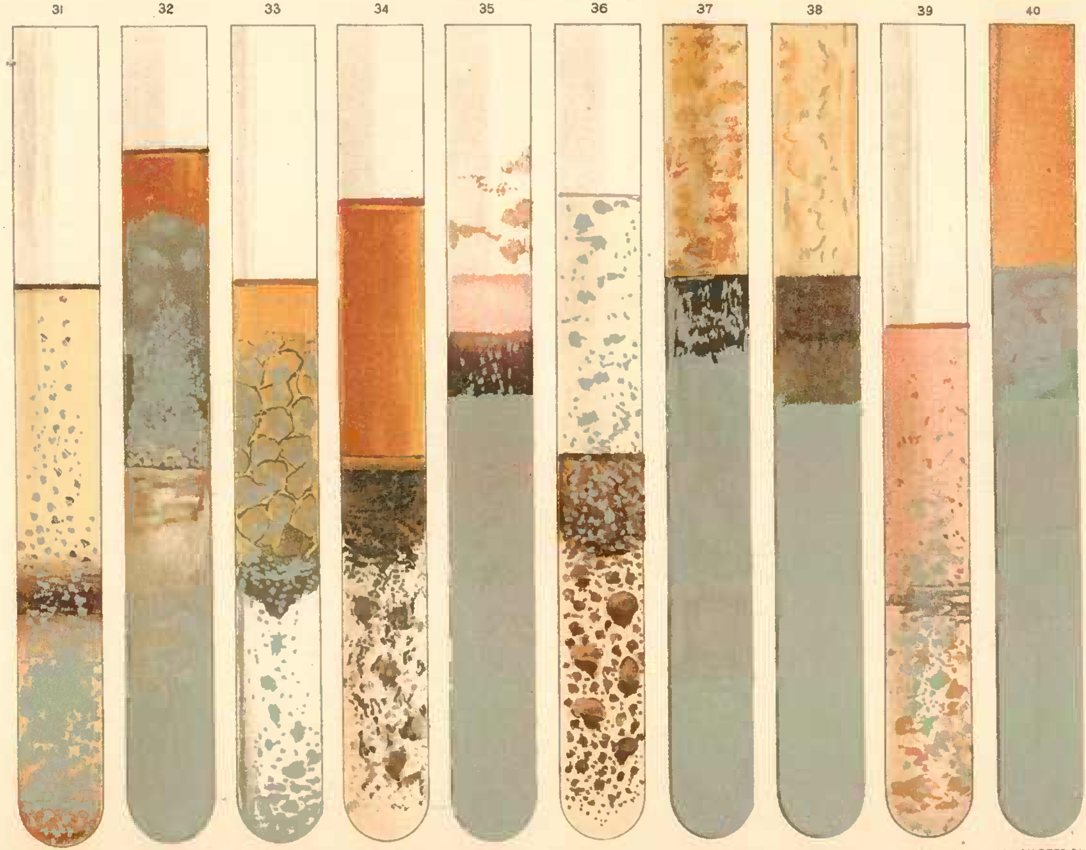


21. COTTONSEED OIL AND OLIVE OIL EQUAL PARTS. PHENOL AND NITRATE
22. COTTON SEED OIL AND NITRATE OF
23. LARD AND NITRATE OF SILVER.
24. MORAJOLO OLIVE OIL PHENOL AND NITRATE OF
25. LARD OIL. PHENOL AND NITRATE OF
26. COD LIVER OIL. PHENOL AND NITRATE
27. VIRGIN OIL (OLIVE) ALCOHOL AND
28. SESAME OIL. PHENOL AND NITRATE OF
29. OLIVE OIL, OF 1890 AND PHENOL NITRATE OF
30. LARD, PHENOL AND NITRATE OF SILVER.

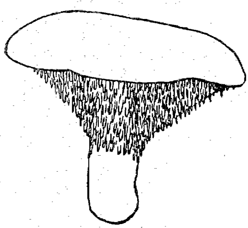
Strobridge Lith Co. N. Y.

NITRATE OF SILVER TEST OF FOOD AND MEDICINAL OILS.

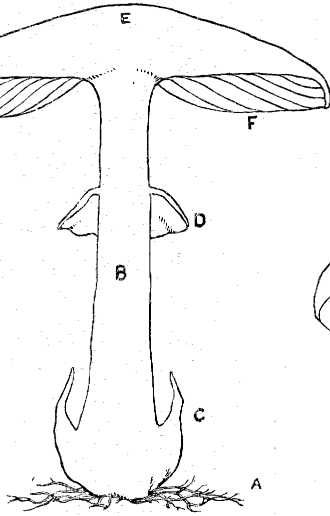
WITH AND WITHOUT PHENOL.



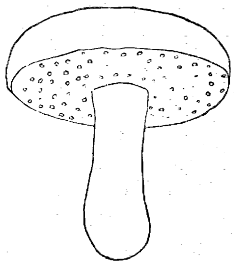
MORAJOLO (OLIVE OIL) | RIVERSID NO.1 (OLIVE OIL) | LINDSEED OIL, WEAK PHENOL | LINDSEED OIL AND | LARD IN BENZINE | LARD OIL AND | COTTON-SEED OIL, PHENOL AND | LARD IN BENZINE, PHENOL | VIRGIN OIL (OLIVE) AND | COTTON-SEED OIL, PHENOL AND



Hydnum.
Spine Mushroom.



Agaricus.
Gill Mushroom.



Boletus.
Pore Mushroom.

A. Mycelium, or spawn.
B. Stipe, or stem.
C. Volva, or wrapper.
D. Annulus, or ring.
E. Pileus, or cap.
F. Lamellæ, or gills.

REPORT OF THE BOTANIST.

SIR: I have the pleasure of presenting herewith a report of the work of this Division for the year 1890. The report contains a general statement of the concerns of the Division and a few short papers on matters of general interest. The articles on forage experiments in Kansas and in Mississippi are preliminary to full reports to be presented for publication as bulletins.

Respectfully,

GEO. VASEY,
Botanist.

HON. J. M. RUSK,
Secretary.

INTRODUCTION.

The Section of Vegetable Pathology having been created into a separate Division, its work will be separately reported upon.

The appropriation for the Botanical Division provides for experiments with forage plants, the development of the herbarium, and other economic botanical work, mentioning specifically that upon medicinal plants.

FORAGE EXPERIMENTS.

Grass Experiment Station at Garden City, Kansas.—The Station was established in August, 1888, with Dr. J. A. Sewall, of Denver, as superintendent. A short account of the plan of experiments undertaken in the year 1889 is given in the report of the Botanist for that year. During the present year these experiments have been continued and others instituted, so that with the added experience of the previous year encouraging indications of practical and valuable results have been attained. A statement of the experiments and processes is given on page 383.

Grass experiments at Agricultural College, Mississippi.—By an agreement between the Secretary of Agriculture and Prof. S. M. Tracy, Director of the State Agricultural Experiment Station of Mississippi, a series of forage experiments has been for two seasons conducted in that State under the direction of the Botanist of this Department and the superintendence of the director of the Station. By this arrangement the expense of leasing land and putting up buildings was saved to the Department, and excellent management of the experiments was insured. The Station itself is benefited by the direct interest of the Department in its forage questions and by its ability to make immediate local application of the results. A preliminary report of this work is given on page 378.

OTHER EXPERIMENTS.

The results attained at the Garden City Station are only in a general way applicable to the whole area of the arid lands. The climatic conditions vary exceedingly, even within this area, and while over a comparatively large portion the experiments and methods here used are satisfactory, for other portions it is necessary to make new experiments and to test the methods first found useful. To accomplish this end arrangements have been made with the United States Agricultural Experiment Stations at Fort Collins, Colorado, and Tucson, Arizona. About 5 acres of land was prepared at each of those stations, and sown to seeds of grasses and forage plants, with very poor results, probably due in part to the newness of the land. The experiments will be continued. Arrangements have been made with the Experiment Station at Las Cruces, New Mexico, and the Experiment Station at Logan, Utah, for grass and forage experiments next season.

HERBARIUM.

During the last two years means have been given to the Division to make collections of plants in little known regions, to provide for their identification, and to publish the results.

During the present year Dr. Edward Palmer, an old and experienced collector, has explored remote parts of Lower California, Western Mexico, and Arizona, making valuable collections, which add materially to the knowledge of the botanical character and resources of those regions. Mr. J. H. Simpson was employed from May to August, inclusive, to collect plants in the region of Manatee, Florida. He collected such species as were known to be rare, or not to have been found there previously, and made an annotated list of all the plants of that district. Mr. G. C. Nealley, of Houston, Texas, has been collecting since April 15, in Western Texas, for the most part in the desert lands. He was directed to make collections of as nearly as possible all the plants seen, and to take note of such as promised to be of value in the forage experiments. The plants collected in 1888, 1889, and the present year form the basis of a flora of Western Texas, now in preparation by Prof. J. M. Coulter under the direction of the Botanist. On the 15th of September Mr. C. R. Orcutt, of San Diego, California, started on a collecting trip for the Department in the Colorado Desert of Southern California. The specimens from this excursion have not yet been received. Other collectors have been employed for shorter periods, and have added materially to the growth of the herbarium.

The continuation of this method of obtaining specimens will enable the Department to have fully represented in the herbarium the plants of regions before little explored, and will insure a valuable stock of specimens for exchange. It will be possible before the lapse of many years to prepare, from the data now accumulating, handbooks covering the botany of the southwestern States and Territories. Since the establishment of the United States Agricultural Experiment Stations, there has been an especial demand for such publications.

In addition to the specimens collected by the Division others have been received in exchange, by purchase, and by contribution, so that the number of sheets added to the National Herbarium during the year July, 1889, to July, 1890, is about 6,000.

Exchanges of specimens from the herbarium have been carried

on ever since its establishment. Most of these exchanges have been made for the purpose of adding desirable specimens to the collection; but with certain institutions, namely, the State Agricultural Colleges, the exchanges assumed the character of a duty. The Division has continued to donate specimens and is desirous to aid the colleges in every practicable way. Within the last few years several of the Experiment Stations, not having access to any herbarium, have applied to the Department for aid, and have received sets of accurately identified economic plants. These sets have been found especially necessary for reference by the Station botanists in the naming of forage plants under experiment.

MEDICINAL PLANTS.

The work on medicinal plants thus far done by the Division has been confined, for want of sufficient means, to the illustration and description, in the Annual Reports, of a small number of native species known to have value in medicine. The object of such reports was merely to enable persons of little botanical education to identify the plants. In certain portions of the United States the collecting of native drugs is an important local industry. It is proposed to continue the investigation of our native medicinal plants, with reference to their commercial and economic relations. It is desirable to make experiments in the collection of such kinds as are becoming scarce in the wild state. Many requests come to the Department for seeds of the well known medicinal plants of foreign countries, with the view of attempting their cultivation. An effort will be made to obtain a supply of seeds of such kinds as are suited to our climate.

PUBLICATIONS.

Until the present year all the publications of the Division, except the Annual Report of the Botanist, were issued in a series of bulletins. The subject-matter of these bulletins was of so varied a nature and was directed to such different classes of readers that it was found desirable to institute a new series of publications to contain matter not of direct economic importance. This was accordingly done, by authority of the Secretary, and the title "Contributions from the United States National Herbarium" was adopted. The economy of this course lies in the fact that a smaller edition of these publications is required, and a separate mailing list is kept for them. The Bulletins henceforward will contain economic reports, the Contributions scientific matter. Since my last Annual Report the following publications have been issued:

Special Bulletin. The Agricultural Grasses and Forage Plants of the United States, by Dr. George Vasey. A new, revised, and enlarged edition, with 114 plates. 1889. (Pp. 1–148, with 114 plates engraved on wood, 8°.)

Bulletin No. 12. Grasses of the Southwest: Plates and Descriptions of the Grasses of the Desert Region of Western Texas, New Mexico, Arizona, and southern California. Part 1. By Dr. George Vasey. Issued October 13, 1890. (Pp. 1–8+100 [unnumbered], with 50 lithograph plates, royal octavo.)

Contributions from the United States National Herbarium, No. 1. Issued June 13, 1890. I.—List of plants collected by Dr. Edward Palmer in 1888 in southern California; by George Vasey and J. N. Rose. II.—List of plants collected by Dr. Edward Palmer in 1889 at (1) Lagoon Head, (2) Cedros Island, (3) San Benito Island, (4) Guadalupe Island, (5) head of the Gulf of California; by George Vasey and J. N. Rose. (Pp. I–VIII+1–28, 8°.)

Contributions from the United States National Herbarium, No. 2. Issued June 28, 1890. Upon a collection of plants made by G. C. Nealley in the region of the Rio Grande, in Texas, from Brazos Santiago to El Paso County. By John M. Coulter. (Pp. I–IV+29–61+ index, 8°.)

INSECURITY OF THE HERBARIUM.

The present insecurity of the National Herbarium from fire is the cause of constant anxiety to those acquainted with its condition. The collections have an actual market value of about $20,000, and as certain portions could never be duplicated if destroyed, an additional value, hardly to be estimated in money, is given. So fully is the necessity of safe quarters realized throughout the United States that the American Association for the Advancement of Science, at its annual meeting for 1890 in Indianapolis, passed resolutions calling the attention of the Secretary of Agriculture and of the Secretary of the Smithsonian Institution to the present insecurity of the Herbarium, and expressing an earnest desire that measures be taken to insure its safety. Taking into consideration the need of safer quarters and the inadequacy of space in the present building, it is earnestly recommended that a commodious fire-proof building, or portion of a building, be provided for the National Herbarium.

MISSISSIPPI EXPERIMENT STATION.

By S. M. Tracy.

In 1888 Congress made provision for the prosecution of experiments in the culture of forage crops, under the supervision of the Department. One of the stations for this work was located at the State Experiment Station at Agricultural College, Mississippi, and placed in charge of S. M. Tracy, the director of the Station. Seeds of all the species which could be found in the markets were procured, and correspondents in India, Australia, and other foreign countries added many additional species. Seeds of the most promising native sorts were collected, and during the past two seasons one hundred and sixty-one species of grasses and thirty-eight of other forage plants have been under test. Nearly all of these have grown on three sets of plots in order to test their value for different soils, and thirty-seven of them have been cultivated in the field on areas of from 1 to 5 acres. Details in regard to the growth and character of each, their probable value for cultivation in the Gulf States, together with results of chemical analyses, digestion tests, etc., will be given in a special bulletin soon to be issued by the Department, while the general results with the leading sorts are summed up as follows:

With so many species, coming as they did from all parts of the world, it was not expected that all, or even many of them, would prove valuable for cultivation under the peculiar climatic and soil conditions which exist in the Gulf States, where the growing season for different plants extends nearly through the year, and where protracted summer drouths and excessive winter rains make it necessary that hay and pasture fields should be able to resist great atmospheric extremes. A large majority of the native forage plants in this region commence their growth late in the spring, but from about the 1st of April until December the pastures are abundant, and certain kinds of hay may be cut at any time from June to November. The great desideratum for this region is a plant which will make a fair growth for pasture during the cool and rainy months of the winter. Whatever may be used for this purpose should be a perennial, so

that fields need not be reseeded often; it should be adapted to great differences in soils; the roots should be able to endure continued drouth, and the forage must be relished by all kinds of stock. We have no plants which continue an active growth throughout the year, so that for a winter pasture plant we are obliged to look for one which will not be choked out and destroyed by other plants which occupy the ground during the summer months. Among those species which have succeeded the best have been the following:

ORCHARD GRASS (*Dactylis glomerata*).—This grass has given us a better winter growth on heavy clay soils, without attention, than has any other species which we have tested. It commences its growth with the first warm days of February, and if not pastured is ready to cut for hay in May, and will then afford excellent grazing until checked by the summer drouth. With the first fall rains it starts a new growth of leaves, making excellent fall pasture, and keeping fresh and green all winter. Its habit of growing in large clumps is against its use as a hay grass, but it bears grazing well, recovers quickly when cropped down, and makes its best growth during the cooler parts of the year.

RESCUE GRASS (*Brumus unioloides*).—This is an annual winter grass which produces even more abundantly than does the orchard grass, when sown on rich and not too heavy soil, but requires more care in its management. If sown in September or October it will usually make a heavy growth during the fall, and is often ready to cut for hay as early as February, and may be cut once or twice more before June. It disappears on the approach of hot weather, and if it is desired to make the field a permanent meadow should not be cut after April, so that the last growth may ripen seed. With favorable rains the seed will germinate in September or October, and will then furnish abundant food during the winter. Where stock can be taken from the pasture in time to permit the maturing of the seed the grass will be practically permanent, but if this is not done it will disappear after two or three seasons. Sown with equal care it will give a better winter pasture than either oats or rye, and in the spring can be plowed under with equal advantage as a fertilizer. When properly handled it is one of our most valuable sorts, but unless it receives attention to secure it an opportunity for self-seeding it can not be relied on to form a permanent sward.

WATER GRASS (*Paspalum dilitatum*).—This is a perennial species which is indigenous throughout the Gulf States, and which seems well worth cultivating. It grows from 3 to 5 feet high, bears drouth well, and will grow on almost any soil. It is somewhat difficult to propagate, as many of the seeds fail to germinate and it spreads slowly from the roots, but when once established it lasts indefinitely, remains fresh and green through the winter excepting for a few days after severe freezes, and is easily killed out when it is desired to bring the field into cultivation. It grows best on low ground, but when it has been planted on dry clay hills it has made an excellent growth, and now (November 15) covers the ground with a dense mass of fresh green leaves. It bears grazing well, is relished well by all kinds of stock, and may be safely recommended for any locality south of latitude 35°. We do not know that the seed has ever been offered for sale.

CARPET GRASS (*Paspalum platycaule*).—This is a perennial species which is indigenous to the southern part of the country, and which has spread northward until it is now found occasionally as far north

as Starkville, Mississippi, but which is not abundant excepting along the coast region. Its flat and spreading habit makes it of no value for hay, but it furnishes excellent grazing during nearly the entire winter. It grows best on rather low lands, and will bear closer grazing and more tramping than any other grass we have. It starts slowly from the seed, but when once established it grows rapidly, and a single plant will cover from 10 to 20 square feet in a season. It roots at every joint like the Bermuda, but unlike that, it can be readily destroyed by cultivation. In favorable locations it occupies the ground to the exclusion of all other plants, even the bitter-weed (*Helenium tenuifolium*) being unable to grow through the close sod. It starts slowly but plants from seed planted in March are now (November 15) 8 feet in diameter and are unchecked by heavy frosts.

TERRELL GRASS (*Elymus virginicus*).—This is another native perennial which has received but little attention, but which is of considerable value for winter pasture. It grows most abundantly along creek banks and on the borders of the woods, but will grow on almost any soil. Its best growth is made during the fall and winter months, and is ready to cut in May, but the hay made from it is rather poor quality. Although a perennial it is best to take stock off the field sufficiently early to allow the roots to become strong enough to stand the summer drouth. Mr. A. S. Yarbrough, of Como, Mississippi, who has grown it for many years, says:

It will stand cold and heat without injury, but it can not stand pasturing in summer. It and Japan Clover are the only forage plants that we need, and about the only ones that are worth growing. If sowed in September on either plowed or pastured land, when the fall rains commence it will begin to grow and be from 2 to 10 inches high by December 15, after which it can be grazed in suitable weather through the winter and spring, when the land ought to be allowed to grow into Japan Clover or Bermuda, but never pastured during the summer.

Experience with this grass at the station indicates that, like the Australian oat, it will be of considerable value under good management, but of little use when it fails to receive the necessary attention.

TEXAS BLUE GRASS (*Poa arachnifera*).—This is one of the most widely advertised grasses in the whole South, but its real value for general cultivation is still problematic. It is a perennial, and emphatically a winter growing species. In favorable locations it begins its growth in October, and from November to May furnishes an abundance of luxurious pasturage. It matures its seed in April, and by the 1st of June the leaves become dry and withered, and little is seen of it until October. It is difficult to propagate from the seed, but can be increased rapidly by means of suckers, which are produced in immense numbers. From the fact that it takes its period of rest during the summer it is able to endure the longest drought without injury, and Professor Shelton reports that it is not injured by cold in Kansas. A rich loamy soil seems necessary for its successful growth, and in many places where the soil has appeared suitable the growth has been disappointing. At the Station it has been planted in a dozen or more places and with varying results. On rich light soil it has made a compact vigorous sod, which fully covered the ground in six months after planting, and has furnished excellent grazing for two years. Planted on equally good and well prepared ground with Bermuda it has lived, but has increased very little, and only occasional plants are to be seen during the late winter and spring months. On dry stiff clay it has nearly all died during the first season, and on the so-called "black prairie" lands

it has succeeded admirably. We have had no trouble in growing it from seed when sowed in beds and cared for, but have failed wholly in three attempts to grow it by sowing broadcast in the field.

RED TOP (*Agrostis vulgaris*).—On low and damp soils this is a valuable grass, as it remains fresh and green throughout the winter, furnishes excellent grazing, and is not easily killed by overflows, even when covered with water for two or three weeks at a time. We have found no better grass for marshy lands and "seepy" hill-sides, and it has done moderately well where the ground was quite dry. During the first season after sowing it makes but little show, but becomes stronger and more dense with age, and maintains itself well against weeds and other grasses. It will produce one cutting of good hay, but its chief value here is as a winter and early spring pasture.

CRAB GRASS (*Panicum sanguinale*).—This grass is found everywhere throughout the south in cultivated fields, where it springs up after cultivation has ceased for the season and makes from 1 to 2 tons per acre of excellent hay. On land which was plowed in February we have cut four crops of about 1 ton each this year. As its best growth is made in cultivated fields, and at a season when other forage is abundant, it is not of special value for grazing, but as the hay made from it is of very good quality, and costs nothing but the cutting, it is highly prized by many farmers.

BERMUDA (*Cynodon dactylon*).—This is one of the most widely diffused and best known of southern grasses, being found in all of the country south of the Ohio River. It is a perennial, but starts late in the season, and is killed down by moderate frosts. It succeeds best on rich bottom lands, where it will yield two cuttings in a season, making from 2 to 4 tons of hay per acre. This hay is of the very best quality, being especially valuable for horses and mules. When once established in a field it is very difficult to eradicate, and this is a decided objection to its general cultivation.

JOHNSON GRASS (*Sorghum halepense*).—This is at the same time one of the most valuable grasses and one of the most troublesome pests to be found in the South. It is a perennial which is easily propagated either by seeds or roots. It makes its best growth on rich bottom lands, where it soon occupies the whole ground, and will give three cuttings of about 2 tons each when in good condition. The hay is of excellent quality and is relished by all kinds of stock. The thick and fleshy roots soon become interlaced and matted in the soil, so that at intervals of three or four years the yield of hay is materially decreased, and the ground should be broken and harrowed, after which the grass becomes as vigorous as when first planted. The planter who wishes to grow hay and nothing else will find this a valuable species. As it requires a loose soil for its growth, it is of but little value for grazing, and but little is seen of it the second season that land is pastured. The objections to its cultivation are the rapidity with which it spreads to fields where it is not wanted, and the great difficulty of eradicating it from fields where it has become established. When fields are pastured it will soon almost disappear, but the roots remain alive and will again take possession of the field as soon as it is plowed. Instances are known where fifteen and even twenty years of continuous pasturing have failed to produce any appreciable effect on the vitality of the roots. It can be killed by covering with salt to the depth of an inch or more, and weekly hoeings

for a year will destroy most of it, but the work must be continued during the second season to make it complete.

Through the Gulf States are a number of forage plants, not grasses, which add largely to both the hay and pasture resources of the country, and which should be mentioned in this connection. The most important of these is Japan Clover (*Lespedeza striata*), which was introduced—probably from Japan—about thirty years ago, and which has now become thoroughly naturalized as far north as the Ohio River. It is an annual, but when introduced it perpetuates itself without care, and will make a fair growth on the poorest and dryest of clay hills. It starts rather late in the spring, making but little show before June, but from that time on it grows rapidly and is eaten greedily by all kinds of stock. It continues its growth until killed by frost. On sterile soil its growth is flat and spreading, and it is fit only for pasture, but where the soil is of good quality it will grow from 20 to 30 inches in height and yield from 2 to 3 tons of hay per acre, which is fully equal in value to the best clover hay, and is probably the most profitable hay which can be grown here for feeding to milch cows or for fattening purposes.

ALFALFA (*Medicago sativa*) has been grown with varying results. On moderately rich and somewhat sandy soils it has proved very valuable for soiling purposes, furnishing cuttings as early as February, with frequent successions until late in summer. It also furnishes excellent winter pasture and is a profitable crop on suitable soils. On heavy clay, and dry hills, its growth has been weak and unsatisfactory. If pastured on alfalfa during the spring, cattle are seldom injured, but if not accustomed to it they are frequently attacked by bloat when turned into a field containing a rank growth, though it is probably no more dangerous in this regard than is red clover.

MELILOTUS (*Melilotus alba*).—This plant bears a close resemblance to alfalfa, but is larger and coarser in every way and is especially adapted to use on calcareous soils. It will make an excellent growth on the "rotten limestone" hills which are so barren that they will sustain no other plants, but is of almost no value on the red clays which contain but little lime. It is not generally liked by animals unaccustomed to its use, but it starts into growth very early in the spring when green forage is scarce, and if stock are turned onto it at that time they very soon acquire a taste for it and eat it readily through the remainder of the season. When grown for hay one crop can usually be cut in the fall, after sowing in the spring; and during the next season two crops may be cut, after which it should be allowed to mature seed. Unless cut early the stems become hard and woody, and in all cases care is necessary in handling in order to prevent the loss of leaves, which drop from the stems very easily. Excellent hay can be made by sowing melilotus on lands which have been set in Johnson grass, the mixture seeming to improve the palatability of both. From land cultivated in this manner we have seen three cuttings, of about 2 tons each, made in a season.

MEXICAN CLOVER (*Richardsonia scabra.*)—This is an annual plant belonging to the *Rubiaceæ* or Madder family, which has been introduced from Mexico. It makes its growth during the latter part of the season, coming up in cultivated fields after other crops have been laid by or removed, and by fall covering the ground with a dense growth of about 2 feet in height, and making a heavy yield of excellent hay. Enough seed will be left on the ground so that it wi

not need to be sowed a second time. The plant is so succulent that the hay is somewhat difficult to cure, but is relished by all kinds of stock. It succeeds best on the sandy lands in the pine woods along the coast, but has made heavy crops when sown on rich soil at the station, and a moderate crop the second season on the same land without plowing. It is excellent for late summer and fall pasture, but is worthless at other times.

Many of the grasses and forage plants which are valued highly in the North have proved of little use when planted here. Among the more prominent are these:

TIMOTHY (*Phleum pratense*), which makes a weak growth for a year or two, but soon succumbs to the encroachments of the more vigorous native grasses and weeds. The apparent reason for this is that the bulbs and roots become so weakened by the continued growth to which they are stimulated during the "warm spells" of winter, that they are unable to withstand the strain of the summer heat and drouth.

KENTUCKY BLUEGRASS (*Poa pratensis*) is also practically a failure here. Where the soil is rich and moist, especially if partially shaded, it will make a weak growth, but will very rarely make the close and even sod so characterestic farther North. Repeated attempts to grow it here have been made during the last ten years, but total failure is the almost invariable result. Occasional patches of it may be seen, but these are not of sufficient size or evenness to be of any value either for pasture or lawn.

MEADOW FOXTAIL (*Alopecurus pratensis*) has done but little better than timothy, though it has afforded slightly better grazing.

None of the Fescue grasses (*Festucas*) have done well. They grow fairly during the cool weather, but the warm summer rains cause them to decay.

The Ray grasses (*Loliums*) have also proved worthless. They start readily from seed sown either in fall or spring and make a vigorous growth till warm weather comes, after which they dwindle and soon disappear. We have succeeded in preserving plots through the summer only with the greatest care, and from five sowings in the field of the Italian, English, and perennial varieties we have nothing left excepting an occasional plant. None of them seem able to stand our long summers, and can not be recommended for the Southern States.

RED CLOVER (*Trifolium pratense*) is of far less value here than in the Northern States. It starts readily, and may be cut two or three times during the season, but usually ceases to grow in July or August, and the fall rains stimulate such a vigorous growth of other plants that the clover is choked out and the next year the stand is "patchy" and irregular. On occasional fields the clover will maintain itself for several years and produce heavy crops, but such fields are quite exceptional.

EXPERIMENT STATION AT GARDEN CITY, KANSAS.

In the Report of the Secretary of Agriculture for 1889, in the botanical part, there was published an account of the organization of an Experiment Station at Garden City, Kansas, for the purpose of experimenting in the cultivation of grasses and forage plants suitable to the arid districts of the West. A statement was made

of the work which had been performed up to that time. I will now continue this report for the present year. The land was plowed and put into as good condition as possible, the newly broken ground was again plowed, the sod cut into pieces with the disk harrow, and further pulverized by means of a special thousand-toothed harrow, invented by the superintendent of the Station, Dr. J. A. Sewall. Two thousand pounds of seeds of native grasses had been collected the preceding autumn, and these, together with several hundred pounds of foreign seeds, were sown. The native seeds were of the following kinds; the amount of land for each kind is given:

Chrysopogon nutans, 2 acres.
Panicum virgatum, 20 acres.
Agropyrum glaucum, 5 acres.
Andropogon provincialis, 2 acres.
Andropogon Hallii, 1 acre.

The foreign grasses were as follows:

Festuca elatior, 5 acres.
Arrhenatherum avenaceum, 1 acre.
Holcus lanatus, 2 acres.
Agrostis stolonifera, 1 acre.
Bromus inermis, 3 acres.
Festuca heterophylla, 2 acres.
Festuca ovina, 2 acres.
Elusine Corocana, 3 acres.
Cynodon dactylon, 1 acre.
Lolium perenne, 2 acres.

Of foreign forage plants were the following:

Sainfoin (*Onobrychis sativa*), one half acre.
Spurry (*Spergula maxima*), one half acre.
(*Lotus major*), one half acre.
Serradella (*Ornithopus sativus*), one half acre.
Goats' Rue (*Galega officinalis*), one fourth acre.
Hairy Vetch (*Vicia villosa* and *Lathyrus hirsutus*), one fourth acre.
Bokhara Clover (*Melilotus alba*), one eighth acre.
Alfalfa (*Medicago sativa*), 10 acres.

In addition there were sowed and planted on the 160-acre field, 40 acres winter rye, sowed in September, 1889; 8 acres Polish wheat, and 80 acres in different varieties of sorghum.

The result for this year, so far as the grasses were concerned, was very disappointing. Most of the kinds germinated and made a satisfactory growth up to June 1, after which for want of rain they suffered sadly, and most of them at the end of the season were complete failures. Of those surviving, the most promising kinds were *Bromus inermis*, *Panicum virgatum* and *Agropyrum glaucum*. The two *Andropogons* and the *Chrysopogons* mainly failed, probably on account of the seed having been collected before it was mature. The failure of some is attributed to being sown on new ground in which the old sod had not become thoroughly disintegrated.

Of the forage plants *Galega officinalis*, *Anthyllis vulneraria*, *Onobrychis sativa*, and *Medicago sativa*, although they suffered much from the drouth, yet maintained life, and with a favorable winter will probably recover vigor the coming spring. There is encouragement to expect this from the fact that the same plants of last year's sowing maintained a vigorous growth in spite of the drouth of this season, some of them even affording a good cutting for hay. The most promising of these are: (1) Sainfoin (*Onobrychis sativa*) (2) Burnet (*Poterium* sp.); (3) Goats' Rue (*Galega officinalis*); (4) Spanish Clover (*Anthyllis vulneraria*).

The *Melilotus alba* or Bokhara Clover made a good crop, as it will no doubt do in the driest season, the only difficulty being that cattle do not like it and have to be trained to eating it. It is maintained, however, by many who raise it in the south that cattle are readily brought to eating and relishing it, and if that circumstance

can be depended upon there need be no want of abundance of forage on the most arid soils. But the discouragements of this year with respect to the growth of the grasses, were partly compensated for in another direction. Knowing that in California, Utah, and Arizona, where perennial grasses have not succeeded, some of the grains, as barley and wheat, are cultivated as forage, an experiment was undertaken with winter rye. About 40 acres of this were sown in September, 1889. This came up and grew well until winter, and in the spring of the present year up to the 1st of June, when the Superintendent of the Station (Dr. J. A. Sewall, of Denver) said it was equal to any rye he had seen in Colorado even with irrigation, and if the rainfall for June had been an average one it was estimated that it would have yielded 25 bushels per acre. About 2 acres were cut and made into hay, the rest grew until it was harvested, when it threshed out about 17 bushels per acre. Another experiment was with Polish wheat (*Triticum Polonicum*). About 10 bushels of this was sown in March and harvested about the 25th of June, maturing in about one hundred days. Up to the 1st of June this was very promising, but the drouth following prevented its full development; still it gave at harvest 8 bushels per acre of excellent wheat of this variety. In fact it attracted a great deal of attention. A sample of it was sent to the State Fair at Topeka, and would have taken first premium had it not finally been ruled out of the wheat list and classed with rye. The surplus of the rye and wheat, after reserving sufficient for the use of the Station, was gratuitously distributed to the farmers of the surrounding country for seed purpose, in quantities of from one half a bushel to 2 bushels, and it was eagerly sought for. The lesson of this experiment is that in the most unfavorable season it seems possible for the farmer to provide a large amount of fodder, as well as a fair quantity of grain, by utilizing the winter and spring rains.

In addition to what has been already mentioned, about 80 acres were planted to different varieties of sorghum, all of which presented an appearance of great thrift up to the 1st of June, when the drouth, and those peculiar desiccating winds to which Kansas is subject, arrested their development and ruined the greater part of the yield, only one variety, locally called Jerusalem corn (apparently a variety of Millo Maize), maintained a good degree of hardiness and vigor and matured a fair crop of seed, which is of great value as a feed for poultry, hogs, and other animals.

These experiments illustrate and emphasize the line upon which such investigations should be pursued. It is very rarely that the seasons fail at both ends of the year, and by a proper selection of grain, grasses, and other economic plants, there will rarely be a total failure of crops. The early maturing winter and spring grains and the hardier kinds of sorghums may be pretty confidently relied upon for food crops and fodder; then there is little doubt that the grasses and forage plants now under trial will prove successful, and other plants, as sugar-sorghum, corn, oats, beans, castor beans, root-crops, etc., may take the chances of the seasons, which three times out of four will probably be favorable to them. Certainly the immense importance of making these arid lands inhabitable will justify most protracted and exhaustive experimental work at this and other stations.

During this year the rainfall at the Station from the 1st of January until the 1st of June amounted to 9 inches, and from the 1st of

June until the 25th of October a trifle over 3½ inches, making less than 13 inches during nearly ten months, considerably less than the average of many years, and sufficient to account for the failure of many of the grasses.

By the kindness of General A. W. Greely, I am able to present a table of temperature and rainfall at Dodge City, Kansas, for a period of sixteen years. This place is on the 100th meridian, a degree farther east than Garden City. It will be noted that there is great irregularity in the amount of rainfall, particularly during the summer months. During the sixteen years given, the quantity for those months varies from 4.67 inches (for 1890) to 18.89 inches (for 1884). Only two other years of the sixteen was the summer rainfall nearly as low as the present one, viz, in 1876, 4.79 inches, and in 1882, 5.63 inches. The chances are that such a dry summer as the present will not occur again in many years, and if the grasses now living can be carried over the year they may be fairly established. The table of temperature gives only the average for each month. I am informed that for many days during the summer, at the Station, the thermometer reached from 103° to 110° in the shade. Very little vegetation can pass through such an ordeal as this intense heat combined with the prevailing drought.

Mean temperature at Dodge City, Kansas, since January, 1875, *as recorded by the United States Signal Service Office.*

Months.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.
January	13.2	35.3	23.9	32.0	23.9	38.2	20.1	31.1	22.1	25.6	18.4	16.5	27.1	22.8	28.9	27.2
February	29.8	41.5	37.1	38.2	32.5	39.3	26.8	38.1	26.2	28.5	25.8	35.0	30.5	37.7	29.0	32.4
March	38.1	34.7	42.6	49.3	47.7	40.2	39.8	46.8	40.8	41.8	40.9	39.0	44.6	36.5	45.8	42.5
April	47.9	56.6	50.1	55.9	57.0	54.8	53.1	52.5	53.0	49.1	54.4	51.0	54.4	56.9	56.6	54.2
May	65.4	64.5	62.7	61.9	68.9	68.2	63.6	56,5	60.5	59.5	58.7	67.5	65.4	60.5	63.7	63.6
June	75.4	71.2	70.6	70.5	76.0	74.7	76.9	73.1	70.5	71.2	71.2	71.2	74.0	74.5	69.8	75.0
July	75.5	79.6	77.5	80.0	80.4	76.4	77.8	74.6	76.2	76.6	76.3	78.2	78.7	80.0	77.5	82.4
August	74.6	77.2	76.2	79.0	75.6	74.8	78.0	73.9	71.7	71.9	73.1	78.3	74.8	74.4	76.9	76.4
September	68.7	66.7	68.4	67.9	66.2	65.8	67.7	68.0	64.1	70.3	66.0	67.6	68.2	67.8	66.3	65.2
October	56.6	52.6	51.7	54.0	59.5	51.6	56.5	56.6	50.8	57.6	57.3	58.8	53.7	55.1	55.6	55.5
November	39.9	38.4	38.6	43.4	40.7	26.2	37.7	40.1	41.8	41.6	45.2	38.1	42.5	41.2	37.4	.....
December	40.7	21.1	39.0	23.8	25.7	24.9	36.9	31.7	34.8	21.0	36.6	28.6	28.9	38.4	44.6	.....
Means	51.0	53.2	53.5	54.4	54.3	52.9	53.0	53.6	51.1	51.2	51.5	52.5	53.6	53.8	54.3	.....

Rainfall at Dodge City, Kansas, since January, 1875.

Months.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.	1890.
January	0.12	0.00	0.18	0.21	0.87	0.00	0.15	0.52	0.44	0.08	0.52	1.82	0.07	0.23	1.69	0.42
February	0.10	0.05	0.56	1.13	0.08	0.00	1.63	0.22	1.42	0.28	0.47	0.46	0.53	0.73	0.34	0.39
March	0.04	3.59	0.25	1.01	0.17	0.04	0.50	0.24	0.42	1.91	0.75	1.50	0.17	0.93	1.38	0.05
April	0.72	0.16	3.38	1.06	0.40	0.11	2.38	0.68	2.40	1.07	1.39	1.90	2.46	4.08	2.12	2.90
May	2.26	1.15	4.96	4.63	0 90	3.01	12.82	3.87	5.41	4.48	4.07	0.40	3.69	2.86	1.54	1.19
June	0.64	2.53	3.92	2.19	4.40	1.59	1.77	1.51	4.31	7.67	2.02	5.47	4.00	5.16	3.43	1.00
July	3.28	2.26	1.79	1.61	3.90	4.00	5.06	3.04	2.61	6.40	6.03	2.07	1.00	4.07	2.02	0.22
August	2.06	1.03	4.09	4.48	3.75	5.17	2.36	1.07	5.66	4.82	1.80	2.46	2.28	3.00	2.14	3.45
September	1.32	2.13	0.50	0.76	0.80	0.32	3.13	0.15	1.32	0.23	3.48	2.33	0.14	0.78	0.86	0.57
October	0.06	1.00	3.34	0.09	0.00	1.42	2.19	1.62	3.32	1.50	1.06	0.45	0.48	0.81	2.88	0.89
November	0.00	1.35	0.56	0.60	0.04	2.43	0.95	0.11	0.12	0.83	0.36	0.24	0.35	0.06	0.77	.....
December	0.09	0.15	4.36	0.19	0.12	0.03	0.61	0.11	1.07	1.10	1.76	0.25	0.54	0.23	0.00	.....
Total	10.69	15.40	27.89	17.96	15.43	18.12	33.55	13.14	28.50	30.36	23.71	19.35	15.71	22.94	19.17	.....

GRASSES FOR ARID DISTRICTS.

Many inquiries are made as to what grasses and forage plants can be tried in the arid districts. In general I will say, such kinds as are observed to thrive and produce a large or at least a fair amount of nutritious forage in the region under consideration. In our experiments we have rather acted on the supposition that any and everything might be given a trial, notwithstanding the probability that nine tenths of all kinds tried would prove failures. Repeated failures with any particular kinds will soon eliminate such from the list of further trials, and cause us to continue work with a greatly reduced number. Yet we may get much help from the establishment of some general principles.

(1) No perennial grasses with broad leaves can be expected to answer the purpose. Such kinds are of vigorous growth and require a large supply of water to come to maturity.

(2) Grasses with strong, deeply penetrating roots, are generally best adapted to endure long periods of drouth.

(3) Grasses with bulbous enlargement at the base of the culm, and these with thickened rhizomas, and those with creeping and rooting stems are generally able to bear drouth on account of the nutriment stored up in their tissues. Some species of Panicum and some of Phalaris are promising kinds, from this peculiarity.

(4) Some kinds produce a large quantity of foliage near the ground, which serves as mulch to protect the soil beneath from rapid evaporation, and are able hence to survive drouth. Of this kind is *Bromus inermis*, a European grass recently introduced; *Lolium perenne*, or perennial rye grass; and *Festuca elatior*, or tall fescue. The common grama grass, *Bouteloua oligostachya*, and buffalo grass, *Buchlœ dactyloides*, owe their value largely to the property of forming a close mat of interwoven stems and leaves upon the surface of the ground. *Sporobolus cryptandrus* and *Sporobolus airoides*, two kinds of wire grass native to the plains, owe their persistence to their hold upon the ground by means of their strong penetrating roots.

(5) Generally the grasses for cultivation in arid soils are to be sought for in the arid country itself. They are existing there, but in small quantities or in special localities, and are waiting to be looked up and brought under the protecting influence of cultivation. True, there are several desert regions where at present agriculture is impossible without irrigation, but even in southern New Mexico and Arizona there are broad elevated plains where water is obtainable within less than a hundred feet, and where there is evidence in the existing vegetation that systematic cultivation of properly selected grasses might be expected to secure a greatly increased production of useful vegetation. The grasses which I would select for cultivation there, are very different from those I would recommend for Kansas and similar northern regions. Among the species I would select in that region are: (1) *Panicum virgatum*, sometimes called Switch grass; (2) *Panicum bulbosum*, with thickened bulblike culms; (3) *Setaria caudata*, a kind of perennial pigeon-grass; (4) *Andropogon scoparius*, or broom-grass; (5) *Phalaris intermedia*, or Wild Canary grass; (6) *Sporobolus airoides*, and (7) *Sporobolus Wrightii*, sometimes called Saccatone; (8) *Pappophorum laguroideum*, with no common name. In addition to those some of the

European grasses and forage plants which are under trial at Garden City may be found suitable.

NOXIOUS WEEDS.

By F. V. Coville.

ORDER COMPOSITÆ.

Horseweed (*Ambrosia trifida*).

[Plate I.]

Plant annual, robust. Stem simple, erect, terete, striate, hispid, 3 to 10 or even 15 feet high, often 1 inch in diameter at the base. Leaves opposite, large, petiolate, 3-lobed, strigose on both surfaces; lobes oblong to lanceolate, acuminate, serrate; upper leaves often oblong-lanceolate and not lobed. Inflorescence a paniculate leafy cyme of slender racemes. Heads monœcious; staminate pendulous at the ends of filiform pedicels (about one fourth of an inch long), with a flat involucre about one fifth of an inch in diameter; pistillate few, sessile at the base of the raceme, 1 to 3 together in the axil of a leafy bract. Staminate flowers minute, several in each head; pistillate flowers single in the head, the involucre surrounding it closely and resembling an ovary. Fruit seed-like, obovoid, slightly compressed, one third to one half an inch long, about 6-ribbed, with several sharp tubercles toward the apex.

Horseweed is a native of the United States, and is distributed throughout the country east of and extending somewhat into the Great Plains. It grows in all tilled soils, but especially in rich river bottoms, forming, if left to itself, a dense growth and choking out most other plants. It is easily subdued by mowing and plowing. In copses and open woods along streams and by the margins of fields it is usually left to mature its fruit, and it is a matter of economy to mow such patches of the plant as often as they flower. The fruit, which exactly resembles a seed, is undoubtedly transported and widely scattered by the floods characteristic of alluvial plains, so that something more than the local extermination of the plant is necessary to prevent its growth.

One correspondent from Texas says that the plant makes a fodder which is freely eaten by horses and cattle.

Orange Hawkweed (*Hieracium aurantiacum*).

[Plate II.]

Perennial by slender rootstocks and by runners. Stem simple, erect, 1 to 1½ feet high, nearly leafless, densely hirsute, the hairs toward the apex of the stem black at the base. Leaves mostly radical, oblong-lanceolate, denticulate, hirsute on both sides, sessile, those of the stem 2 or 3, all but the lowest reduced to bracts. Heads in a bracted-cyme; peduncles with black glandular hairs and a close brown coating of stellate hairs; involucre about one third of an inch in diameter, its bracts linear-lanceolate, little imbricated, provided on the back with straight, glandular, and stellate hairs. Flowers all perfect, with ligulate orange-colored corollas. Achenia about 1 line long, dark brown, linear in outline, terete, 10-ribbed, truncate; pappus a row of dirty-white capillary bristles.

This plant has been recently introduced into the eastern United States from Europe. It has appeared thus far mostly in pastures and roadsides, where the grass is not tall, a single plant giving rise in a few years, by its rootstocks and runners, to a large patch tenacious of life and taking almost complete possession of the soil.

When to this characteristic is added its capability of producing a large number of seeds adapted to dispersion by the wind, an idea of its pestiferous nature may be obtained. The orange colored flower heads are strikingly pretty.

ORDER SCROPHULARIACEÆ.

Toad flax (*Linaria canadensis*).

[Plate III.]

Plant perennial, spreading by rootstocks. Stem erect, usually unbranched, commonly 1 to 2½ feet high, smooth. Leaves numerous, alternate. sessile, linear to linear-oblanceolate, 1 to 2½ inches long, one twelfth to one fourth of an inch broad, acute at the apex, smooth. Flowers short-pediceled in an erect terminal raceme, elongating as it flowers to a length of sometimes 8 inches. Calyx of 5 ovate acute sepals about one sixth of an inch long, not enlarging in fruit. Corolla pale yellow, the parts united into a tube, irregular, 2-lipped, the orifice closed, three fourths to 1 inch long, with a straight, downwardly projecting spur; upper lip 2-lobed, erect; lower lip 3-lobed, bearded at the base, reflexed, spreading, middle lobe much the smallest. Stamens 4, borne on the base of the corolla-tube, anthers included. Ovary 2-celled; placentæ axile; ovules numerous; style 1, filiform, not projecting from the corolla; stigma capitate-bilobed. Fruit an ovoid obtuse pod. Seeds small, flat, circular, surrounded by a wing.

In appearance this is a pretty and, in mass, a striking plant, but when bruised it has a characteristic rank odor. It is native in Europe, but fully naturalized in the eastern United States in pastures, meadows, and roadsides. When once started in a place it spreads rapidly and persistently by its long rootstocks underground. Its favorite situation is in rather dry soils, and careful and persistent cultivation is required to exterminate it.

ORDER CONVOLVULACEÆ.

Clover dodder (*Cuscuta trifolii*).

[Plate IV.]

Plant annual, parasitic without chlorophyll. Roots none. Stem filiform, yellow, twining, attached to its host by sucker-like disks. Leaves reduced to inconspicuous scales. Flowers white, about one half of an inch broad, in small glomerate clusters. Sepals 5, ovate acute. Corolla gamopetalous, twice as long as the calyx, 5-lobed; lobes spreading, acute. Stamens 5, inserted on the corolla, each subtended by a large ciliate scale. Styles 2. Stigmas 2, elongated, not ciliate. Fruit a circumscissile capsule.

This parasite is a native of Europe, supposed to have been introduced into the United States with clover seed. It has appeared occasionally in various parts of the United States and within the last two years has been prevalent in Missouri.

There are twenty-one species of Cuscuta native in the United States, all leafless twining plants, with filiform stems, parasitic on various hosts. Three introduced species are known: One from Chili on alfalfa, another from Europe on flax, and the third the one under consideration. Clover dodder may be readily distinguished from all our other species, except flax dodder, by its elongated instead of capitate stigmas, and from that species by growing upon clover instead of flax.

A clover field usually becomes infested with the parasite from the sowing of seed containing that of dodder. The dodder seeds germinate in the ground, sending up slender leafless stems, which twine

about the clover and obtain nourishment from it through the disks that are soon developed. The lower part of the stem then dies and connection with the ground is lost. The yellow threads continue to develop rapidly until a circular patch of clover is covered by it, and the host becomes so weakened by the loss of its sap that it finally turns brown, dies, and rots.

The remedy is first to obtain a pure quality of clover seed. Dodder seeds are similar to those of clover, but of smaller size and capable of separation by screening. If a meadow is but slightly infested, each patch containing the parasite should be mowed and destroyed as soon as seen, and if no plants are allowed to seed the clover will be saved. When, however, a meadow is thoroughly sprinkled with dodder the whole must be plowed and other crops planted for a few years, when all the dodder seeds will have germinated and died. Under no circumstances should an infested crop be saved for seed.

ORDER PLANTAGINEÆ.

English Plantain (*Plantago lanceolata*).

[Plate V.]

Plant perennial. Rootstock short, thick, nearly erect. Leaves all radical, long-petioled; blade oblong-lanceolate to linear-lanceolate, acute or acuminate at both ends, 3 to 5, rarely 7 ribbed, denticulate, from pilose to nearly smooth, 3 to 6 inches long. Inflorescence a solid spike about one third of an inch in diameter, from 2 inches long to very short, borne on a naked slender scape about twice as long as the leaves. Flowers perfect, single in the axil of an ovate, 1-nerved, papery bract shorter than its flower. Sepals 3 (one composed of two united), papery, ovate; one 2-nerved, the others 1-nerved. Corolla in one piece, with four abruptly spreading, ovate, 1-nerved lobes, each about 1 line long. Stamens 4, borne on the tube of the corolla, not extending from it. Ovary 2-celled, 2-ovuled. Seeds 2, oval, rather flat, hollowed on one face, about 1 line long.

This plantain has long been naturalized in the United States, coming originally from Europe. It is now found throughout almost the entire country, in pastures, meadows, and lawns. Its seed is easily distinguished from that of grasses and other forage plants, which should always be examined before planting. If the weed is once established, plow it under and cultivate the soil for a year or more.

It has often been used as a forage plant in England, but in the United States it has proved thus far undesirable.

ORDER GRAMINEÆ.

Bur Grass (*Cenchrus tribuloides*).

[Plate VI.]

Plant annual. Stem spreading and branching at base, from a few inches to 3 feet high. Leaves of the stem 3 to 10, usually glabrous; blade 6 inches long or less, 1 to 2 lines broad, flat or sometimes involute. Inflorescence a spike of burs, these consisting of a cluster of two or three spikelets inclosed in an involucre provided with barbed spines and bristles. Flowers in each spikelet 2, one staminate, the other fertile, grains when mature remaining inclosed in the involucre.

This native grass is common throughout the southern portion of the United States and Mexico, extending northward in warm, sandy regions into the Northern States. In some parts of the Great Plains it takes almost entire possession of cultivated fields late in

the season, ripening its grains for the next year, and offering great annoyance to cattle and to men. The barbed spines easily penetrate the flesh and are painfully irritating.

Thorough cultivation should be adopted until the crops are harvested, and after that sufficient plowing to prevent the maturing of the grains

NEW FODDER GRASSES.

We add here the figures and descriptions of two grasses which are considered as having much value for fodder in the South. They would have been included in a former publication but that the plates could not be prepared in season.

ORDER GRAMINEÆ.

Pearl Millet, Cat-tail Millet, Egyptian Millet (*Penniscetum typhoideum*).

[Plate VII.]

A tall, erect, thick-stemmed grass growing to the height of 6 feet or more. It has an abundance of broad leaves and is terminated by a spike-like panicle, which is compact and cylindrical; a foot long, and resembling the common cat-tail. The panicle is studded with small obovate grains, which are surrounded at the base by numerous coarse hairs or bristles. It is probably a native of the East Indies, where it has long been cultivated, and forms an important article of food. It is also cultivated in Arabia and in Central Africa. It has been cultivated in the Southern States for fodder and on rich ground produces an enormous yield. It may be cut several times during the season, and after cutting sends up numerous sprouts with broad, succulent leaves, and juicy sweet stalks. On rich ground it produces so abundantly as to make it difficult to find room to cure it into fodder. Cattle and horses are very fond of it both green and when cured. It is an annual, and will not mature its seeds except in a warm climate.

ORDER GRAMINEÆ.

Teff (*Eragrostis abyssinica*).

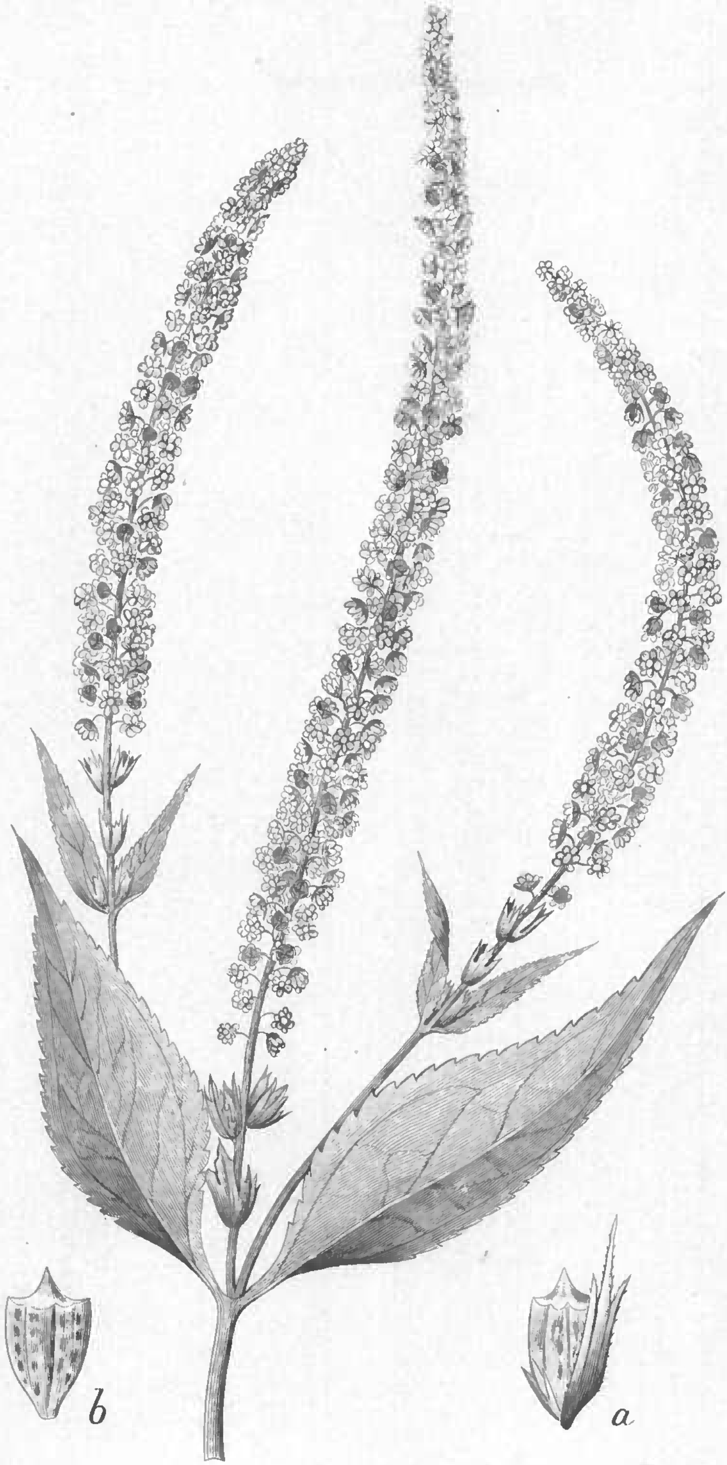
[Plate VIII.]

An annual grass growing to the height of 2 or 3 feet. The stem is rather weak and branching, the large top when in fruit bending over gracefully. The panicle is large and diffuse, the branches fine and much subdivided, the spikelets small, several flowered, and on slender pedicels.

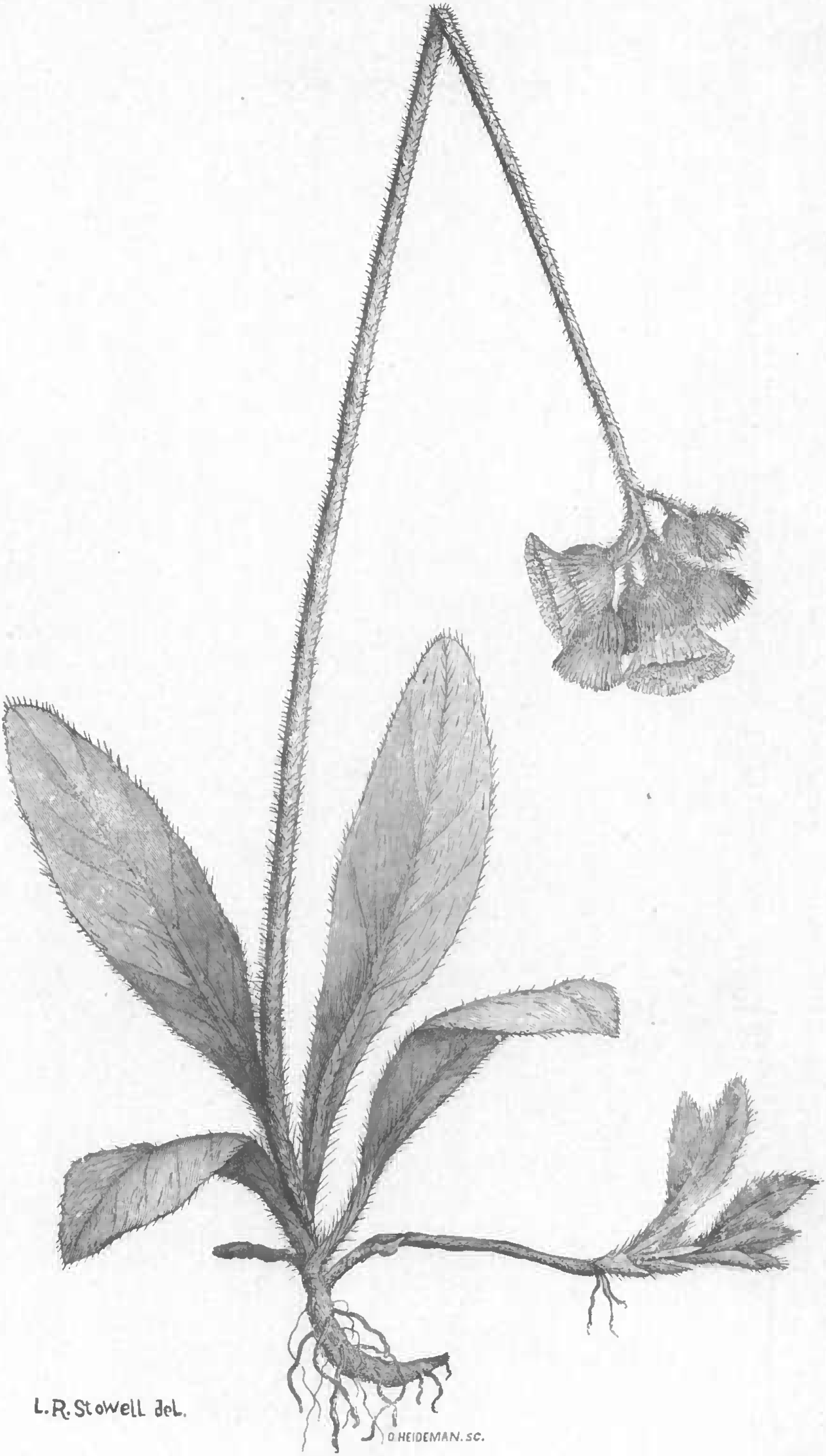
This grass was introduced from Abyssinia, where it is cultivated under the name of Teff, and is used by the natives as food. It has been cultivated in some of the Southern States, and is said to be remarkably productive and valuable for hay. It may be cultivated at altitudes of 6,000 to 7,000 feet, where maize can hardly thrive. It is said to mature in four months and to yield forty times its weight of seed. The traveler, Bruce, mentioned Teff with approval. It is said to make a white, delicious bread. The seed has been diffused by the Royal Botanic Garden of Kew, England, and recently by this Department to several of the Experiment Stations, where it is undergoing a trial.

LIST OF PLATES.

REPORT OF THE BOTANIST.



HORSE WEED (AMBROSIA TRIFIDA).

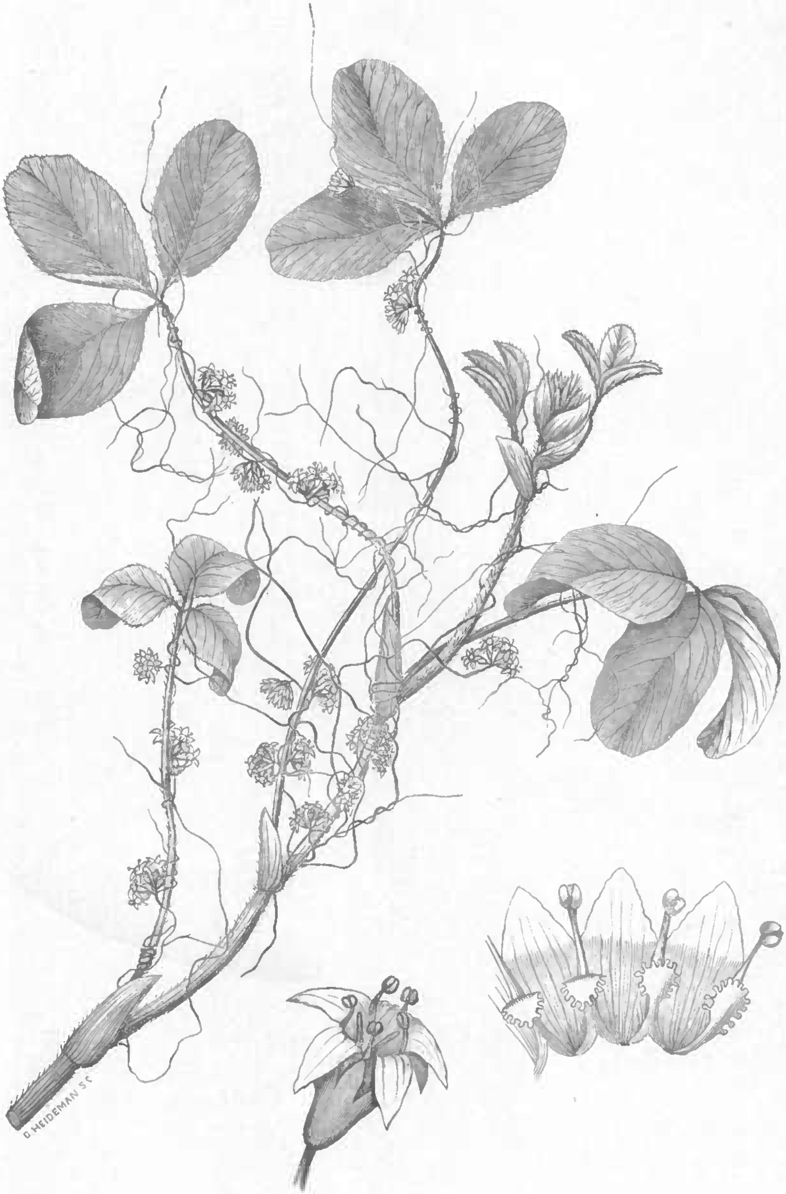


L. R. Stowell del.

O. HEIDEMAN, SC.

ORANGE HAWKWEED (HIERACIUM AURANTIACUM).

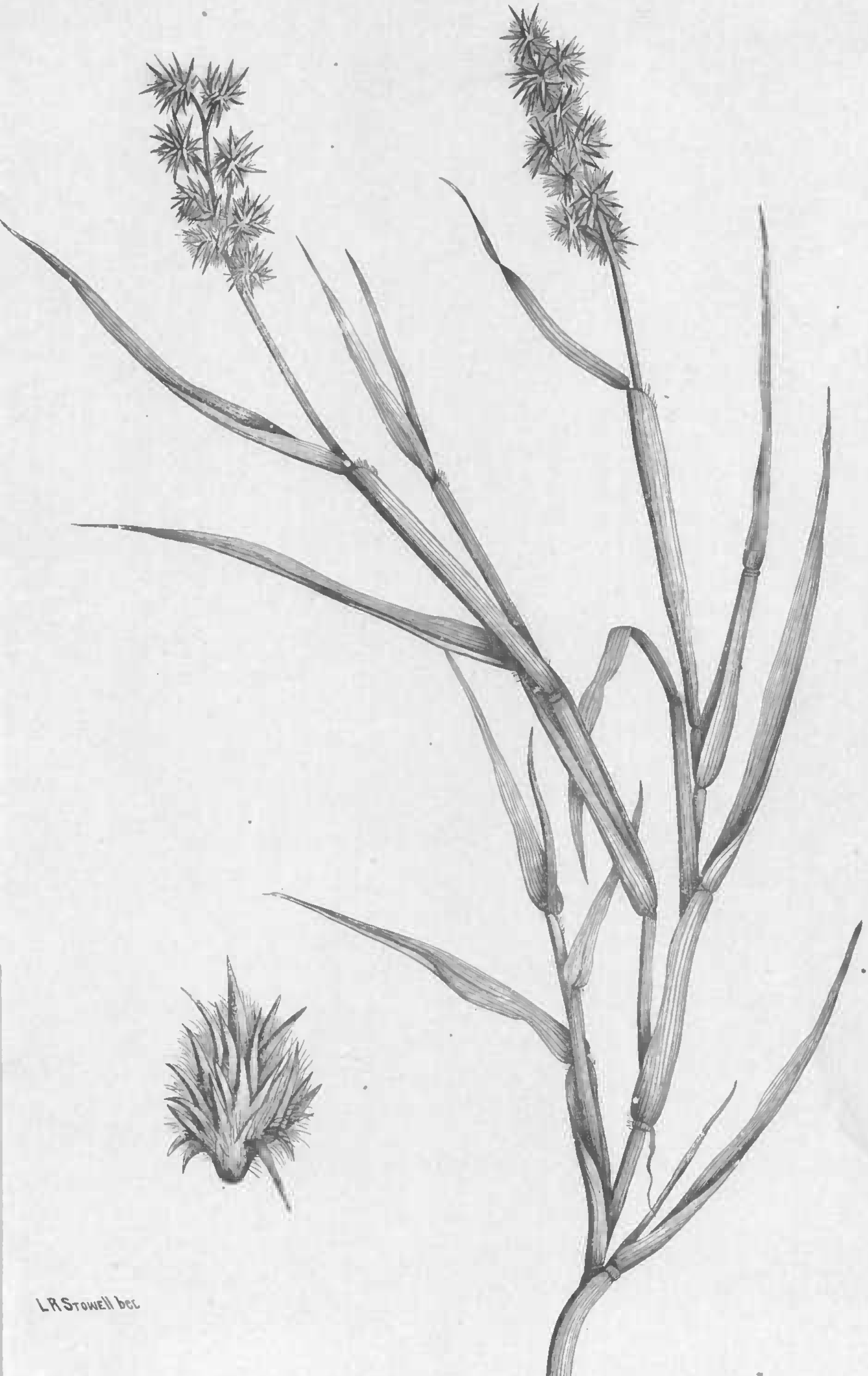
TOAD FLAX (LINARIA VULGARIS).



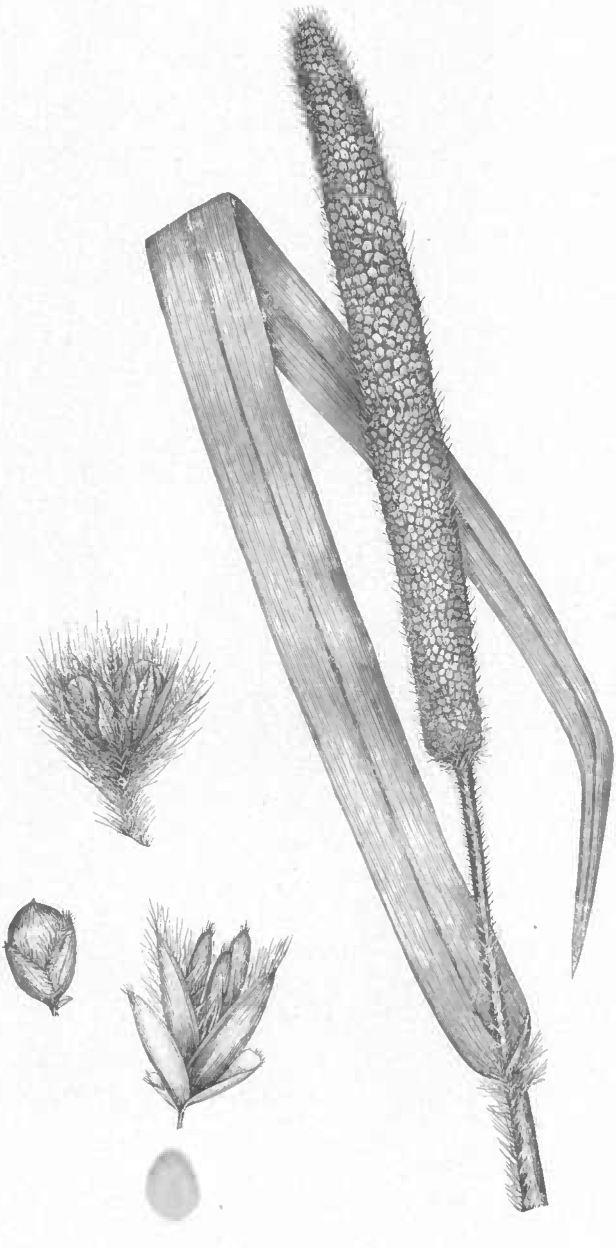
L. R. Stowell del.

CLOVER DODDER (CUSCUTA TRIFOLII).

ENGLISH PLANTAIN (PLANTAGO LANCEOLATA).

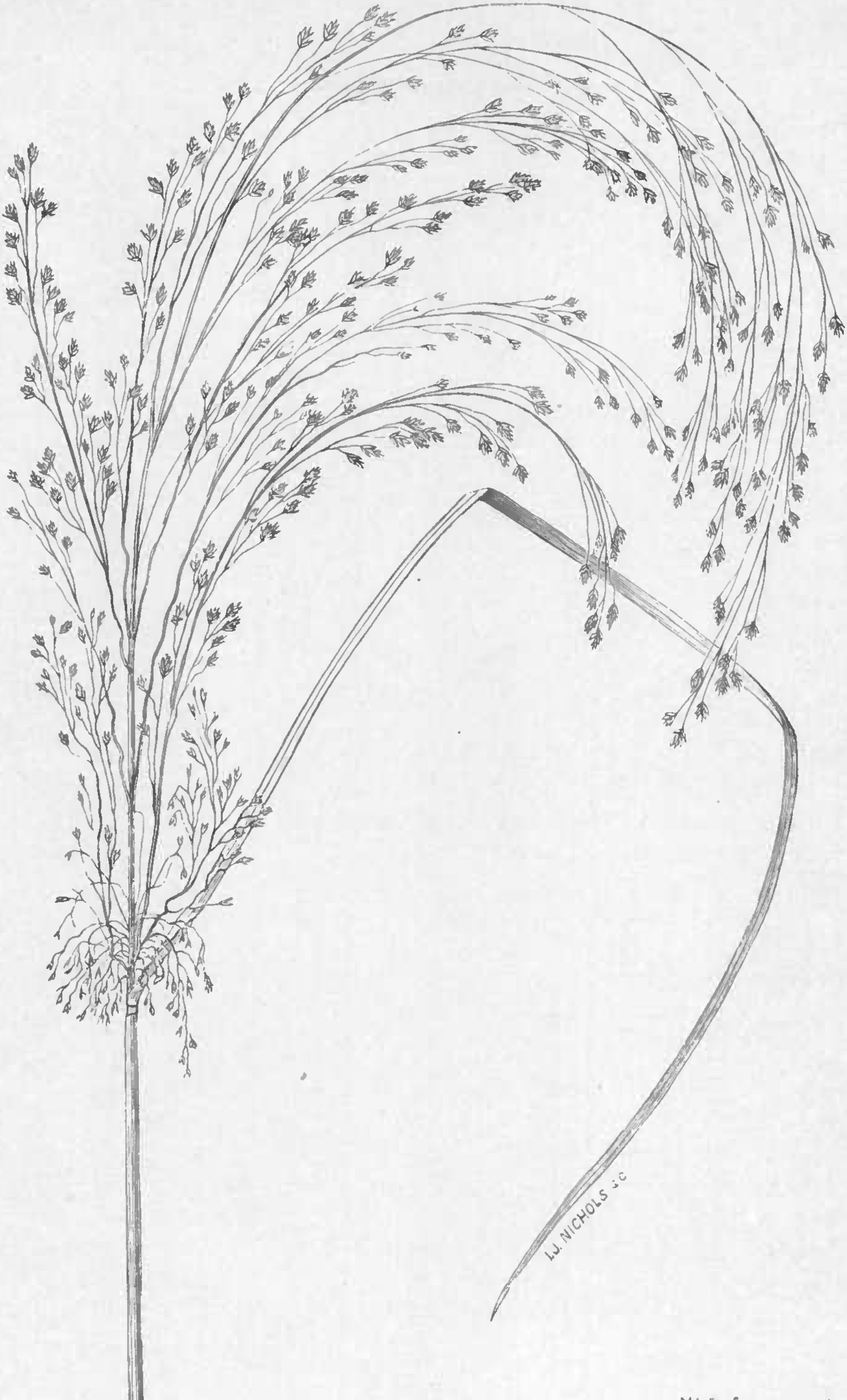


BUR GRASS (CENCHRUS TRIBULOIDES).



PEARL MILLET (PENNISETUM TYPHOIDEUM).

PLATE VIII.



TEFF (ERAGROSTIS ABYSSINICA).

REPORT OF THE CHIEF OF THE DIVISION OF VEGETABLE PATHOLOGY.

SIR: I have the honor to submit herewith my annual report for the year 1890. As heretofore, the report embodies only a brief summary of the work accomplished in this Division during the year, the details having been published in various bulletins and circulars already issued.

Respectfully,

B. T. GALLOWAY,
Chief of the Division of Vegetable Pathology.

Hon. J. M. RUSK,
Secretary.

WORK OF THE DIVISION.

GENERAL BUSINESS.

Under this heading may be mentioned care of correspondence, preparation of bulletins and circulars, work on the herbarium, indexing literature, and properly classifying and filing the same.

During the year nearly three thousand letters were received and answered, this work consuming fully one third of my own and assistants' time. The writing, indexing, filing, and general care of the letters requires nearly the whole time of two clerks.

Since my last report the Division has published, in addition to the regular annual report, one special bulletin and four numbers of THE JOURNAL OF MYCOLOGY. The special bulletin contained 120 pages and embodied the results of experiments made in 1889 in the treatment of plant diseases. The JOURNAL contains numerous papers, both scientific and practical, and as an important means of quickly and effectively disseminating information I can not conceive of anything more useful. During the year the edition was increased 500, but such has been the demand for it that every number but the last is now exhausted.

The general care of the herbarium requires the work of one assistant, while indexing, filing, and general supervision of the literature consumes a considerable part of the time of another.

The force practically remains the same as last year, the assistants being Miss E. A. Southworth and Mr. D. G. Fairchild. Erwin F. Smith is still in charge of the peach yellows investigation and Newton B. Pierce of the California vine disease. Pear blight and several other diseases have received attention at the hands of Mr. M. B. Waite.

LABORATORY WORK.

During the year the principal diseases under investigation in the laboratory were pear blight, a bacterial disease of oats, sweet potato diseases, anthracnose of the cotton and hollyhock, peach yellows, the California vine disease, pear scab, cherry leaf blight, grape diseases, and diseases of greenhouse plants, particularly of the carnation and violet.

A new disease of the grape appeared the latter part of September in several parts of New York State. The matter was investigated by Mr. Fairchild and found to be a malady which has been known for some time in certain parts of Europe. The disease manifests itself in the form of red or purplish spots on the leaves, the latter soon becoming brown and withered, and finally falling, leaving the fruit to shrivel or else mature imperfectly. In Mr. Fairchild's report, which was published in THE JOURNAL OF MYCOLOGY, Vol. VI, No. 3, the disease is fully described, its causes pointed out and suggestions made in regard to preventing it.

In connection with the laboratory work on pear blight Mr. Waite visited Georgia during the months of February, March, and April, making, while there, a series of field tests with fungicides, and also collecting such data as only field investigations render possible.

The work on peach yellows and the California vine disease is given more in detail under their respective headings.

FIELD EXPERIMENTS.

A special effort has been put forth during the year to make the field experiments as thoroughly practical as possible. With this end in view I have spent considerable time in the field myself and have also kept one or more of my assistants constantly engaged in work of this kind. I am more than satisfied with the results of the work, as we have been able to obtain facts which would not have been possible had we depended on field agents exclusively.

I believe that to obtain the best results in practical experiments, such as we are conducting, we must either do the work ourselves or place it in the hands of men having a thorough knowledge of plant diseases. Such men, with possibly here and there a rare exception, are as yet to be found only in some of our experiment stations; it is by coöperation with these that we are able to secure the very best results at comparatively little expense to the Department and practically none to the Stations. Our coöperative work this year with the Wisconsin Station has proved eminently satisfactory, both to us and the Station, and the expense to both has been less than half what we usually pay for field agents.

EXPERIMENTS NEAR WASHINGTON.

This work was conducted wholly by myself and assistant, Mr. D. G. Fairchild, the diseases under treatment being black rot of the grape, pear leaf-blight, and pear scab.

Treatment of black rot of the grape.—For this experiment a vineyard belonging to Capt. J. O. Berry, situated 12 miles southwest of Washington, was selected. The vineyard consisted of about one thousand Concord vines, sixteen years old, and trained to stakes 8 feet high. It had not borne a pound of fruit for several years on

account of rot, thus furnishing the very best means of thoroughly testing the value of the fungicides.

<table>
<tr><td>I.
203.
Bordeaux mixture.</td><td></td><td>II.
221.
Ammoniacal copper carbonate.</td></tr>
<tr><td colspan="3">V.
Untreated.
179.</td></tr>
<tr><td>III.
167.
Copper carbonate in suspension.</td><td></td><td>IV.
183.
Bordeaux mixture and ammoniacal copper carbonate.</td></tr>
</table>

The vineyard was divided into five plats, as shown in the accompanying diagram. The diagram also shows the number of vines in each plat and the treatment it received. The experiment was not made to discover a remedy for black rot, for this question had been settled already. The main object of the work was to determine, if possible, (1) the best means of applying the fungicides; (2) the relative value of the fungicides mentioned in the diagram, and (3) the amount of copper found at the close of the season on fruit treated with the Bordeaux mixture. Each plat was sprayed eight times, first on May 1, and afterwards at intervals of fifteen days, except the last treatment, which was made at the expiration of twenty days.

As regards vigor of vines there was considerable difference in the various plats, hence it was not expected that the yield for each division would be uniform, even if all were treated alike.

In applying the fungicides three spraying machines were used, namely: the Eureka, the Japy, and Nixon's Little Giant. The Eureka and Japy pumps are of the knapsack pattern, while the Nixon is a cart machine holding 40 gallons. It is drawn by hand and is provided with two hose connections, an agitator for keeping the liquid stirred up, and 16 feet of hose. After a thorough trial of all of the machines the Little Giant was selected as the one best suited to our wants. With it we were able to treat four rows at a time, doing the work as thoroughly and rapidly as we could spray two rows with the knapsack pumps.

There is no doubt that, in certain situations, such as on steep hillsides, where the vines are trellised, the knapsack pumps will be found to work to the best advantage. Also where a person has only a small vineyard, of say, not more than 3 or 4 acres, such a pump will be all that is required. For large vineyards horse-power machines should be used. Some of these pumps drawn by two horses and worked by two men and a boy will spray an acre of vines in thirty minutes.

In all cases we used the Improved Vermorel nozzle and lance and we can say without hesitation that for our work we have not been able to find anything better.

As to the relative value of the treatments, cost, etc., a full account

is published in THE JOURNAL OF MYCOLOGY, Vol. VI, No. 3. I only give here some of the more important conclusions taken from this report. They are as follows:

(1) On Plat I, treated with Bordeaux mixture, there was saved $32.40 worth of fruit at an expenditure of $6.51, leaving a profit of $25.89, or 397 per cent. On Plat II, treated with ammoniacal copper carbonate solution, there was saved $25.92 worth of fruit at a cost of $4.32, leaving a profit of $21.60, or 500 per cent. On Plat III, treated with copper carbonate in suspension, the value of the fruit saved was $6.48, the cost of treatment $2.25, leaving a profit of $4.23, or 188 per cent. On Plat IV, treated with Bordeaux mixture and ammoniacal solution, the value of the fruit saved was $19.44, the expense of treatment $3.34, leaving a profit of $16.10, or 482 per cent.

(2) While the amount of fruit saved by the Bordeaux mixture was greater than that by the ammoniacal solution the latter preparation is after all the cheapest. In other words, there was more profit in using the ammoniacal solution than the Bordeaux mixture.

(3) A mixed treatment consisting of Bordeaux mixture and ammoniacal solution is more profitable than a treatment of Bordeaux mixture alone, but not as profitable as the ammoniacal solution alone.

(4) There is nothing whatever to be gained by treating with the carbonate of copper in suspension when the ammoniacal solution is at hand.

In regard to the amount of copper found on the grapes at the time of harvest it was shown that a person would have to eat from a ton to a ton and a half of fruit to obtain a poisonous dose of this salt.

Treatment of pear, cherry, and strawberry leaf-blight as affecting nursery stock.*—This work was conducted in the nurseries of Franklin Davis & Co., situated on the Pennsylvania Railroad about 25 miles northeast of Washington. The details of the experiment as well as those given under the next heading will be published in THE JOURNAL OF MYCOLOGY, copies of which will be sent on application.

The work so far as it relates to the experiments in the treatment of pear leaf-blight was in the main a repetition of that done last year. This season, however, a number of new fungicides were tried but none of them proved as satisfactory as the Bordeaux mixture. The discovery that this preparation, when properly applied, will prevent this most injurious disease, marks an era in successful nursery work. During the present season the nurseries of Mr. Davis were visited by tree-growers from all over the country and in every case they expressed the greatest satisfaction at the results of the treatment. Mr. Davis's abiding faith in the copper remedies, and especially in the Bordeaux mixture, is shown by the fact that this season he used over 2,500 gallons of the latter alone. Briefly stated, the most satisfactory method of treating the disease under consideration is to spray first with the Bordeaux mixture when the leaves are about two thirds grown, then follow with other applications of the same preparation at intervals of about twelve days until five or six sprayings in all have been made. The cost of such a treatment need not exceed 75 cents per thousand trees.

This year for the first time, as far as we are aware, a systematic endeavor was made to control a disease of the cherry which has come to be known among nurserymen as leaf-blight. This disease attacks the cherry leaves about the middle of June or the first of July, caus-

**Entomosporium maculatum*, Lév., *Cylindrosporium padi*, Karst., *Sphærella fragariæ*, Tul.

ing them to at first become spotted then turn yellow and fall. Frequently the trees will be completely defoliated before the middle of August, and as a result growth is checked and the plant is stunted.

In treating the disease the present season the best results were obtained from the use of the ammoniacal copper carbonate and the Bordeaux mixture. As far as the efficacy of the two fungicides is concerned there is little choice. The ease with which the ammoniacal solution is prepared and applied, however, makes it more desirable in the end. The treated trees retained their foliage until frost, and in many cases made a growth of nearly 2 feet more than the untreated. Six sprayings in all were made, beginning on May 1 and continuing at intervals of twelve days. The total cost of the treatment for trees three years old was approximately one fourth of a cent per tree.

As the experiments in the treatment of strawberry leaf-blight do not necessitate any elaborate details, we will give an account of the work in full.

On April 18 a plat of the Wilson strawberry containing five rows each 90 feet long and running north and south was staked off and prepared for treatment. The ground sloped gently towards the south and had evidently been somewhat neglected, as the plants were thickly matted and full of weeds. The rows were numbered 1, 2, 3, 4, and 5. On the 28th of April rows 1 to 3, inclusive, were sprayed, while the others were left unsprayed for comparison. At this time considerable leaf-blight had already appeared, but the plants were in nowise seriously injured by the disease. Of the three rows treated No. 1 was sprayed with ammoniacal copper carbonate solution; No. 2 with Bean's sulphur powder one half pound to 5 gallons of water; No. 3 with potassium sulphide solution, one half ounce to 5 gallons. The sprayings were repeated on May 13 and May 23.

The cost of the treatment, including labor in preparing and applying the remedies, chemicals, etc., was, for the plat treated with the ammoniacal copper carbonate solution, 13 cents; plat treated with Bean's powder, 8 cents; plat 3, treated with potassium sulphide solution, 3½ cents. Basing our estimates on these figures the cost of treating an acre with each of the foregoing preparations would be approximately as follows: For the ammoniacal solution, \$21; Bean's powder, \$12; potassium sulphide solution, \$6. We feel safe in saying that in treating as much as an acre the cost would be lessened at least 25 per cent.

At the time of the second spraying it was an easy matter to distinguish the row treated with the ammoniacal solution on account of its brighter and more thrifty foliage, comparatively free from leaf-blight. The other rows at this date were all badly diseased, there being little if any difference between the treated and untreated. On May 23, when the last spraying was made, the difference between the row treated with ammoniacal copper carbonate and the others was even more striking than when noted ten days previous. What made the result of more interest and importance was the fact that a portion of this same row which extended beyond the experimental plat and which in consequence was not treated, was as badly diseased as the unsprayed rows of the plat.

Treatment of pear leaf-blight and scab in the orchard.—In addition to our nursery work in the treatment of pear leaf-blight it was thought best to make some attempt to prevent the injury to fruiting pear trees from the attacks of the leaf-blight and scab fungi.

This work was carried on in the orchard of Dr. W. S. Maxwell, near Still Pond, Maryland.

In the case of pear leaf-blight an attempt was made to throw some light upon the following questions: (1) The relative value of the Bordeaux mixture, the ammoniacal copper carbonate solution, a solution of copper acetate, copper carbonate in suspension, and mixture No. 5, as preventives of this disease; (2) the number of sprayings necessary to obtain the best results; (3) the proper time of applying the remedies; (4) the cost of the various treatments.

Summing up briefly the results it may be said that so far as effectiveness of the various preparations is concerned they stand in the order named:

Bordeaux mixture (Plate IV), ammoniacal solution (Plate V), copper acetate 3 ounces to 6 gallons of water, mixture No. 5, copper carbonate in suspension.

The difference between the effects of the Bordeaux mixture and of the ammoniacal solution was scarcely perceptible, so that taking the cost into consideration the latter would be preferable.

As regards the number of sprayings and the time of making the same it was found that three early treatments were just as effective as six made at intervals throughout the season. It was further made evident that one late spraying with either Bordeaux mixture or the ammoniacal solution would save a large percentage of the foliage, the former preparation proving much more effective in such a test.

The cost of the various treatments was as follows:

Treatment.	Cost of fungicide per tree.	Cost of application per tree.	Total per tree.
	Cents.	*Cents.*	*Cents.*
Bordeaux mixture, one spraying	1.7	1.1	2.8
Bordeaux mixture, three early sprayings	6.93	3.4	10.33
Bordeaux mixture, three late sprayings	7	4.8	11.8
Bordeaux mixture, six sprayings	15.1	8.7	23.8
Ammoniacal solution, one spraying	.61	.83	1.44
Ammoniacal solution, three early sprayings	3.32	5.6	8.92
Ammoniacal solution, five late sprayings	3.6	3.5	7.1
Ammoniacal solution, six sprayings	7.2	8.2	15.4
Mixture No. 5, six sprayings	8.6	9	17.6
Copper acetate, three sprayings	4.3	5	9.3
Copper acetate, six sprayings	12.4	9	21.4
Copper carbonate in suspension, five sprayings	6.8	6.5	13.3

In the treatment of pear scab the same fungicides used in the preceding experiments were employed, the cost per tree being practically the same. The conclusions drawn from the results of this work are:

(1) Early treatments, *i. e.*, before the fruit is half an inch in diameter, are absolutely necessary to prevent the scab.

(2) Spraying after the fruit is half grown is liable to injure the latter.

(3) The Bordeaux mixture and ammoniacal solution are the only preparations which give really satisfactory results.

COÖPERATIVE EXPERIMENTS.

Similar arrangements to those of last season were this year made with the director of the Wisconsin Experiment Station by means of which Prof. E. S. Goff, horticulturist of the Station, was enabled to carry on a series of experiments under our direction. The work was

conducted on the fruit farm of Mr. A. L. Hatch, $3\frac{1}{4}$ miles southeast of the village of Ithaca, Richland County, Wisconsin, the diseases treated being apple-scab, blackberry and raspberry leaf-blight, and potato rot.*

Experiments in the treatment of apple scab.—These were planned with a view of obtaining some information upon the following questions:

(1) The comparative efficacy of the ammoniacal copper carbonate solution, Bean's sulphur powder, mixture No. 5, and copper carbonate suspended in water.

(2) The value of spraying previous to the opening of the flowers.

(3) The number of treatments necessary to secure the best results.

In this work many important facts were brought out, the most prominent of which may be summarized as follows:

(1) In seasons of excessive rains in early summer the scab on badly infested trees can not be wholly prevented by the treatments given in this experiment.

(2) That of the substances tested mixture No. 5 was the most efficient.

(3) Early treatments, especially previous to the opening of the flowers, are extremely important.

(4) Sprayings in midsummer are at best of doubtful value.

(5) On trees badly affected with scab the fruits that develop may be so far reduced in size by the fungus as to diminish the crop nearly 20 per cent. This, moreover, is doubtless a small part of the injury produced.

Raspberry leaf-blight—This was treated with the Bordeaux mixture and mixture No. 5. The disease, which is caused by a fungus known as *Septoria rubi*, makes its appearance on the leaves often as early as the middle of June in the form of whitish or faintly brownish spots. The spots frequently become so numerous as to completely cover the leaf, and as a result the latter dries up and of course becomes utterly useless to the plant. When fruiting canes are attacked in this way the fruit never matures or if it does it is small, dry, and tasteless. The varieties of raspberries selected for the experiment were Cuthbert for red and Tyler and Gregg for black; those of the blackberry were Stone's Hardy and Ancient Briton. All were growing in somewhat dense rows, and at the time of the first spraying, May 31, presented a thrifty appearance and gave promise of a good crop of berries. At this time the leaves were nearly full grown and the flower buds, though visible, had not yet opened. Forty feet of row of each variety selected for the experiment were treated at the different sprayings with each of the fungicides named. Treatments were given on May 31, June 5, 18, 28, July 7 and 14. In the treatment of June 28 the Tyler and Cuthbert raspberries were omitted, as there were unmistakable indications of injury to the foliage. In the treatment of July 7 and 14 all of the raspberries were omitted as the fruit was beginning to ripen.

It was shown by these experiments that—

(1) The foliage of the raspberry is delicate and can not endure applications of a corrosive nature.

(2) The foliage of the blackberry, though more resistant than that of the raspberry, is more susceptible to injury than that of the apple.

(3) None of the treatments given are to be recommended for the raspberry, and of the materials used only the copper carbonate solution can be pronounced beneficial in the case of the blackberry.

---

* *Fusicladium dendriticum, Septoria rubi,* and *Phytophthora infestans.*

Experiments in the treatment of potato-rot.—The results of this work, which was carried on under my direction by Professor Goff, are eminently satisfactory. Without going into details, which will be published in a special bulletin, I will say that the Bordeaux mixture was applied six times, the result being an increase in the yield of the treated plats over the untreated of from 25 to 50 per cent with comparatively little expense.

WORK OF FIELD AGENTS.

The field agents this year were located in New Jersey, Virginia, South Carolina, and Missouri, their work for the most part being confined to experiments in the treatment of grape diseases. As the reports of these agents can not well be condensed I have reserved them for publication in a special bulletin.

SOME PRACTICAL RESULTS OF THE TREATMENT OF PLANT DISEASES.

The question has occasionally been asked what is the real value in dollars and cents of the treatment of plant diseases. Everyone who has carried on work of this kind knows how difficult it is to obtain exact reports, especially from farmers, fruit growers, and others who, as a rule, make no pretense to skill in bookkeeping. In a few cases, however, we have been able to collect reliable data which show what can be accomplished by proper care and attention to details. In the case of Mr. Berry's vineyard, already mentioned, 777 Concord vines were made to yield $84.24 worth of fruit at an expenditure of $17.42, a clear profit of $66.82. This result, it must be borne in mind, was obtained from an experimental vineyard where the object was not so much the production of a large yield of fruit as to test the relative value of a number of fungicides. It is safe to say that had we used the Bordeaux mixture on the entire vineyard the value of the yield would have been increased to at least $100, while the expense of treatment per vine would have been materially decreased.

Mr. D. M. Wyngate has a large vineyard near Marlborough, New York, and at my request has furnished a careful estimate of the profit derived the present season from treatments suggested by this Division. His vineyard contains 7,450 Concord and 1,000 Delaware vines. The vineyard last year was not treated and yielded 19,690 pounds of fruit, which sold for $625.87. This year the same vineyard was treated seven times, as follows:

(1) March 1, simple solution of copper applied to canes and posts.

(2) Just before blossoming with Bordeaux mixture B.

(3) Just after the grapes had formed with Bordeaux mixture same as 2.

(4) July, same as 2 and 3.

(5, 6, and 7) At regular intervals between July 10 and August 25, with eau céleste.

The total cost of the foregoing treatment, including a Eureka sprayer, was $112.52, divided as follows:

Eureka sprayer	$21.50
Material	38.52
Labor	52.50
Total	112.52

The yield of fruit this season was 53,430 pounds, which sold for $2,181.39. Thus it will be seen that the yield for 1890 (treated) exceeded that of 1889 (untreated) by 33,740 pounds, while there was a net increase in the profits of $1,555.52. It might be said that the season of 1890 was a better one for grapes than that of 1889, hence the increased yield: to obtain definite information on this point Mr. Wyngate left fifty of his vines untreated and they yielded only 40 pounds of fruit totally unfit for market. On this basis his entire vineyard, if not treated, would have yielded 6,760 pounds of inferior fruit worth perhaps $600. Mr. Wyngate, in concluding his report, places his profits for the season, as a result of the treatment, at $1,800 over all expenses.

Prof. L. D. Chester, of the Delaware Experiment Station, has for the past two years been making a series of trials in the treatment of black rot of the grape. Professor Chester has kept a careful record of the facts bearing upon the question under consideration, and his results may be briefly summed up as follows:

A vineyard of 1,088 vines which in 1888 yielded only 250 pounds of fruit was treated in 1889 with the Bordeaux mixture at a total cost of $36.10. As a result of the treatment the yield of grapes was increased to 2,953 pounds, which sold for $144.40, leaving a balance of $108.30. This year the same vineyard was again treated at an expense of $27.80. The yield was 7,451 pounds of fruit, which sold for $560.90, leaving a balance of $533.10. In two years Professor Chester has been able to increase the average yield of this vineyard from one fifth of a pound to 8.47 pounds per vine.

Turning now to another class of plant diseases we will give the results of a series of experiments personally conducted the past two seasons in the nurseries of Franklin Davis & Co., near Baltimore. In the spring of 1889 this firm set out a block of 50,000 pear seedlings with the expectation of budding them the following July. As a rule seedlings of this kind are attacked by leaf-blight* as soon as the foliage appears, and in consequence it is a rare thing that more than half of the buds take. In the hope of saving the foliage the Bordeaux mixture was applied seven times during the season at a total cost of $60, and as a result less than one tenth of 1 per cent of the buds failed to take. This year the same treatment was continued at an additional expense of $60. Many of the buds have made a growth of 10 feet during the season and as the block now stands it is worth fully $7,000. From control experiments and from the experience of previous years it is safe to say that this amount is fully double what the trees would have been worth had they been left untreated. These facts are sufficient to bring out clearly the point we wished to make, namely, that spraying for plant diseases can be done at a handsome profit. In the light of our present knowledge the work must be regarded as a legitimate part of one's business. In other words the farmers, gardeners, and fruit growers who neglect such work at the present day are as much to blame for short crops as those who fail to perfectly manure and cultivate the soil.

FUNGICIDES AND SPRAYING APPARATUS.

During the year a number of new fungicides have been prepared and tested by the Division; at the same time several marked improvements were made in apparatus for applying the same.

Entomosporium maculatum, Lév.

Of the new fungicides the most promising is the one sent out under the name of mixture No. 5. This consists of equal parts of ammoniated sulphate of copper and carbonate of ammonia, thoroughly mixed and put up in air-tight tin cans. It was prepared for us by Rosengarten & Sons, of Philadelphia, at a cost of 45 cents per pound. In most cases we used it at the rate of 12 ounces to 22 gallons of water, but for tender foliage, such as the cherry, blackberry, peach, and young grapes, this is too strong. Another season an endeavor will be made to determine if this amount can not be reduced without affecting the efficacy of the preparation. Mixture No. 5 gave excellent results in the treatment of apple scab; it also proved highly efficacious as a remedy against mildew and black rot of the grape. Much, however, remains to be done in the way of thoroughly testing the fungicide, especially in the matter of finding some means by which it may be prevented from injuring the foliage.

Some of the advantages the mixture possesses over other copper preparations are (1) cheapness, (2) ease with which it is prepared, and (3) the fact that it can be put up in small quantities, only requiring to be dissolved in water when it is ready for use. This last matter is one of considerable importance, as it will enable a great many people to use a fungicide who do not care to take the trouble of preparing the Bordeaux mixture and other similar preparations.

Copper acetate, which has already been used in France, was given a thorough trial in the treatment of a variety of plant diseases. It was used in various strengths varying from 3 to 6 ounces to 25 gallons of water, the usual method of preparing being to dissolve the copper in 5 or 6 gallons of water, allowing this to stand over night and then diluting the next day when ready for use. In no case did the preparation prove of any great value; in fact, in a number of instances, when it was used on young pears and cherries, it was positively injurious. We do not on this account wish to discourage further trials of it, but when it is used considerable caution should be exercised in applying it.

As stated in another part of this report, an endeavor was made to test the efficacy of the Bordeaux mixture when prepared in advance. The mixture was put up for us by a manufacturing chemist in Philadelphia in the following manner:

The copper and lime solutions were made in the usual way, and after mixing, the preparation was allowed to stand for a few hours or until the sediment had all gone to the bottom of the vessel. The clear liquid was then drawn off and thrown away while the pasty sediment, which is of a light-blue color, was slowly dried. This dried sediment was sent to us in the form of a coarse powder put up in 10-pound tin cans. It was used at the rate of 10 pounds to 25 gallons of water in the treatment of pear leaf-blight, downy mildew, and black rot of the grape. Without going into the details of the experiments made to test the efficacy of the preparation we will simply say that in no case did it prove as effectual as the Bordeaux mixture prepared in the usual way. We found it a difficult matter to keep the powder in suspension; moreover, the solution was washed from the leaves by the slightest rain. It is possible that some of the objections may be overcome, but I doubt very much if the mixture prepared as described will ever prove as satisfactory as that made in accordance with the old formula. For those who may wish to put the mixture on the market I would suggest that they put the copper and lime in separate cans, in this way simply furnishing the materials in convenient form

and allowing the farmer or fruit grower to do his own mixing. At the present prices 4 pounds of copper and 5 of lime, which is sufficient for 22 gallons of the liquid, could be canned and labeled, in fact, fully prepared and sold for 10 cents a pound at a moderate profit.

In addition to the foregoing, experiments were made with a modified formula of the ammoniacal copper carbonate solution. This was prepared by mixing together 1½ pounds of pulverized ammonia carbonate and 3 ounces of copper carbonate. In using, the mixture was dissolved in half a pail of hot water and then diluted to 25 gallons. While this solution seemed to give as good results in the treatment of pear leaf-blight as the old formula it is not as satisfactory for several reasons. In the first place its preparation takes considerable time, as the ammonia carbonate must be pulverized. Again, it is a difficult matter, at least in inexperienced hands, to prevent the ammonia from losing its strength. Finally, it is a trifle more expensive than the ammoniacal solution prepared in the usual way, 25 gallons costing 35 cents and this for materials alone.

Professor Chester, of Delaware, who was, I believe, the first to suggest the use of this mixture, prepares it at an expense of but 25¼ cents for 100 gallons. He uses, however, but 2 pounds of ammonia carbonate and 6 ounces of copper carbonate for 100 gallons. Even of this strength the copper alone would cost about 40 cents if bought in the market. Professor Chester, however, manufactures his own copper carbonate at an actual expense for materials alone of but 14 cents per pound. His method of preparing it is as follows:

> Dissolve in a barrel 25 pounds of copper sulphate in hot water. In another barrel dissolve 30 pounds of sal soda in hot water. Allow both solutions to cool, then slowly pour the solution of sal soda into the copper sulphate solution, stirring the same. Fill the barrel with water and allow the precipitate of copper carbonate to settle. Upon the following day siphon off the clear supernatant liquid which contains most of the injurious sodium sulphate in solution. Fill the barrel again with water, and stir the precipitate vigorously into suspension; again allow the precipitate to settle and again on the following day siphon off the clear liquid. This operation washes the carbonate free of most of the sodium sulphate which contaminates it. Make a filter of stout muslin by tacking the same to a square wooden frame which will just fit over the open top of the second barrel, letting the muslin hang down loosely so as to form a sack; through this filter the precipitate so as to drain off the excess of water, and as the filter fills remove the precipitate, and allow it to dry in the air, when it is ready for use. The operation is not troublesome, and can be carried on in connection with other work.

Professor Chester says that 2 pounds of commercial sulphate of copper, costing 5⅗ cents per pound, and 2.5 pounds of soda, costing ¼ cent per pound, will make 1 pound of carbonate of copper. Carbonate of copper prepared in this way can of course be used in the preparation of the usual ammoniacal solution, and the cost of 22 gallons of the same will be reduced from 34 to approximately 16 cents.

Experiments were made by several of our field agents and also by myself to test the efficacy of copper carbonate suspended in water. Three ounces to 25 gallons was the usual strength adopted, but the results obtained were far from satisfactory. This question as well as others pertaining to the subject will be fully described in a forthcoming bulletin containing the reports of field agents.

In the matter of spraying apparatus a new knapsack pump and several improvements in older machines have been designed by the Division during the year. The need of a cheap, durable, and effectual knapsack pump has long been felt in this country, where up to the present season there was only one similar instrument manufac-

tured. The machine designed by us, including a copper reservoir, force pump, spraying nozzle, and lance, can be made for $12. A description, with working drawings of the apparatus, has been published in THE JOURNAL OF MYCOLOGY, Vol. VI, No. 2.

Owing to the expense of using copper for reservoirs an endeavor was made to substitute indurated fiber ware in its place. This ware, which is made from wood pulp, is light, durable, and cheap. Moreover it does not corrode even when our strongest chemicals are used. We have had several reservoirs made from it, and with the exception that it has been difficult to make tight connections where brass or copper are used they have given satisfaction. We are assured by the manufacturers that fittings of any kind can be permanently and tightly inserted in the reservoir if it is done when the latter is "green," *i. e.*, before it is indurated or cured. If this is the case, we see no reason why the fiber ware should not eventually come into use for work of this kind.

An effort is being made to induce manufacturers of spraying machines to adopt some uniformity in the matter of nozzle attachments. As it is, nearly every manufacturer has a size of his own, in consequence of which one is often forced to use a nozzle not wholly suited to the work or else go to the expense of having the proper fittings made. At the last meeting of the Association of Agricultural Experiment Stations Mr. Fairchild, my assistant; Mr. William B. Alwood, of the Virginia Station; and Mr. James Troop, of the Indiana Station, were appointed a committee to inquire into this matter and bring about, if possible, some change looking toward the object under consideration.

PEACH YELLOWS INVESTIGATION.

Laboratory work.—Beginning with November, 1889, about five months were given by Dr. Smith to bacteriological and histological study. This line of inquiry has not, however, been completed, and it would be out of place to draw conclusions from what has been done already. Much additional investigation will be necessary before we can speak decisively. This part of the investigation was crowded out in the spring of 1890 by field work, but will be resumed as soon as possible.

The work already done may be summarized as follows: Two suspected organisms have been isolated from the diseased tissues grown on and in various nutrient media, and studied as carefully as time permitted. Both are short rods (*Bacilli*). Both were found in nearly every diseased tree, but they appeared so rarely that grave doubts have arisen as to their disease-producing nature. If the disease is due to a microörganism it must be rather abundant, judging from the results of bud inoculations. To complicate matters, three yeasts were also isolated under conditions which render it almost certain that they came only from the inner bark. These also were rare. At that time no peach trees suitable for inoculation were at hand. These have since been grown from seed procured in three localities free from the disease, and are now ready for the inoculation.

Field investigation.—This work has been prosecuted continuously since early spring in Delaware, Maryland, Georgia, Michigan, and Kansas. Additional bud inoculations have been made and some further light has been obtained from both the new and old experiments. The results of this part of the investigation will be pub-

lished as a separate bulletin. They may be summarized as follows: (1) The disease can be conveyed to healthy trees by the insertion of diseased buds. Additional proof of this has been obtained. (2) It may also be conveyed by the use of buds which appear to be perfectly healthy, but which have been taken from trees showing yellows on other branches. The difference in this case is that the disease does not manifest itself so quickly. (3) An additional experiment will be undertaken on a large scale to determine whether the disease may also be communicated by buds cut from trees which seem to be perfectly healthy in all parts but which stand in orchards where the disease prevails, *i. e.*, to determine whether the disease has a long period of incubation, as begins to seem probable.

The peaches budded on Mariana plum stock have been set in three orchards in the place of diseased trees. None have yet contracted the disease but it is too soon to speak definitely.

The experiments with fertilizers have been continued another season with the same personal attention to details. To avoid possible unsuspected sources of error, it is thought best to continue the treatments and include the observations of another year before making a definite report. It may now be said, however, that the other line of investigation (histological and bacteriological) seems to offer the most hope of a successful issue. Should the results of next year confirm those of 1889 and 1890 it may be set down as certain that genuine peach yellows can not be prevented or cured by the use of fertilizers.

In addition to the foregoing Dr. Smith has devoted considerable time to the study of a disease which has attracted considerable attention in various parts of the country. The disease is described in THE JOURNAL OF MYCOLOGY, Vol. VI, No. 4, under the name of the Peach Rosette.

THE CALIFORNIA VINE DISEASE.

The investigation into the nature of the vine disease which has destroyed the vineyards of some of the finest vine-growing regions of California is being steadily pursued.

Following the work indicated in my last report, during the rainy season when field work became impossible, Mr. Pierce, the special agent in charge of the investigations, undertook such laboratory work as could be followed with the facilities at hand. A brief examination into the pathological histology of the vine was made, and the search for parasitic fungi and microörganisms continued; the latter were often found, many times in a state of division. Material from the root system, obtained from various points in the affected district, was studied for the purpose of learning the constancy of such forms of fungi as are found in diseased roots at Santa Ana. One especially common form was figured.

During the early part of March, after having considered the necessity and advisability of widening the field of observation, Mr. Pierce was granted a leave of absence for five months without pay in order that he might visit certain parts of Europe and study there a number of vine diseases which, according to published accounts, somewhat resembled the California trouble.

The entire time was devoted to an active review of the workings of the vine diseases of the Mediterranean region. After passing from the northern to the southern portion of France, the leading

vine regions of the southern departments were visited from below Bordeaux to the Italian line. A portion of this same region was again visited upon his return from Algeria. From France he entered Italy, and after first briefly visiting the vineyards and many of the leading scientists of northern and central Italy, Naples was chosen as a center of work for the South. The diseases of the province of Naples and adjoining provinces had his attention for upwards of seven weeks. From Naples he passed to Sicily, continuing the work at Messina, Catania, and Syracuse, and in the western portion of the island at Palermo, Marsala, and Trapani. Those regions where Mal Nero has done its worst work received most of his time.

From Marsala, in southwest Sicily, steamer was taken for Pantelleria and Tunis. Some 600 or 700 miles of travel were made through the regency of Tunis and departments of Constantine and Algiers. Several stops were made in the vine-growing sections.

His trip comprises over 15,000 miles of travel, and that portion bordering the Mediterranean was full of interest to the pathologist and fruit grower. Numerous diseases not yet known in America were encountered, and American affections were observed under new and very interesting conditions. Many facts of interest and value to the fruit grower have been collected, more especially to Californians, as the climate and flora of the two regions are quite similar. A report embodying the results of Mr. Pierce's investigations up to the present time is now being prepared, and it is hoped to have it in the hands of the printer within a few months.

In addition to Mr. Pierce's work an extended series of experiments were made by me in Washington with a view of determining the contagious or noncontagious nature of the disease. Healthy Muscat of Alexandria grapes were obtained from New York and inoculated in various ways with diseased material from California. The most common method of procedure in this work was to graft diseased Muscat wood upon healthy roots of the same variety. Other methods, such as inarching diseased and healthy canes, planting healthy vines in soil obtained in California from around dead and dying roots, etc., were tried, but in no case was any positive evidence of the transmissibility of the disease obtained. A peculiar fact noted in connection with these investigations was that nearly all of the diseased vines recovered as soon as they were placed in the open air. In the greenhouse, however, they never made a continuously healthy growth, but I attribute this largely to the fact that the roots being in pots were crowded, hence did not perform their functions normally. As further proof of this, healthy plants treated in the same way behaved exactly like those from California.

Along with the foregoing there was made a series of bacteriological investigations, something over three hundred cultures being made from various parts of diseased vines. While some evidence of a promising nature was obtained as a result of this work, the facts accumulated are not sufficient to warrant me in making any positive statements.

SPECIAL SUBJECTS.

Summaries are given below of three papers prepared by my assistant, Miss E. A. Southworth, to appear in full in THE JOURNAL OF MYCOLOGY. The subjects are of considerable economic importance, especially the anthracnose of cotton which threatens to be a troublesome disease.

HOLLYHOCK ANTHRACNOSE.

Colletotrichum malvarum (A. Br. & Casp.) South.

[Plate I.]

This is a disease which has been known to florists only five or six years. It is especially destructive to seedlings under glass, but attacks outdoor plants as well; and wherever it makes its appearance destroys a large part or all of the crop. It has quadrupled the price of hollyhocks in New York City in the last three years, and has nearly put an end to growing them for ornamental purposes in the Government grounds. The disease is caused by a parasitic fungus, which may live in any part of the plant. If it attacks the lower portion of the stem, as it is almost sure to do in time, it runs down to the root and kills the plant.

In order to gain all possible information as to the conditions which were favorable, or otherwise, to the life of the fungus causing the disease, a circular of inquiry was sent to some prominent florists. The answers revealed the following facts: (1) Greenhouse plants are more susceptible than others to the disease; (2) putting diseased plants out of doors *sometimes* checks the disease; (3) heat and moisture favor the development of the fungus.

An experiment in the use of Bordeaux mixture and ammoniacal copper carbonate as preventives of the disease was made in a large New York greenhouse. The results were only moderately satisfactory. Very little effect was observed from the ammoniacal solution, but the lot treated with Bordeaux mixture was much more vigorous and was much more free from the fungus than the unsprayed. The foreman of the greenhouses was so encouraged by the results that he decided to spray the plants out of doors as well.

ANTHRACNOSE OF COTTON.

Colletotrichum gossypii, South.

[Plate II.]

This disease was first brought to our notice in 1888; and since that time we have received many complaints and inquiries concerning it. It is especially destructive to the bolls, which it attacks before they are ready to open, stopping their growth, causing them to crack open, thus exposing the immature cotton fiber to the action of rain and dew and to the attacks of insects. Under these circumstances the cotton decays and the crop suffers accordingly. In this way our correspondents report that they lose from 10 to 25 per cent of their crops.

The effects described are found to be due to the action of a parasitic fungus very closely resembling the one causing the hollyhock disease. It has been found to possess great vitality, being able to live for weeks in the heated air of a laboratory. The spores produced by the fungus have also been shown to be capable of producing the disease in a healthy boll; both facts pointing to the necessity of removing diseased plants from the field, and of practicing rotation of crops. Plans are being made to test the value of fungicides for this disease during the next cotton-growing season. The mode of growing cotton renders it possible to apply fungicides rapidly and economically; and an intelligent cotton-grower, who has suffered some loss from the

disease, has generously offered his assistance in field experiments having this object in view. It is therefore hoped that by another year we shall have something definite in the way of preventing the disease.

RIPE ROT OF GRAPES AND APPLES.

Glœosporium fructigenum, Berk.

[Plate III.]

The Annual Report for 1887 contained a full account of what was then called "bitter rot of apples." About two years ago a fungus very like the one causing this disease was found on the grape. The fungus was carefully studied and it was ascertained that spores from the grape would produce bitter rot on the apple, and *vice versa* that spores from the bitter rot of apples would produce the fungus and consequent decay in the grape. In the latter, however, the rotting grapes do not have the bitter taste characteristic in the apple.

These facts give rise to a confusion in regard to the name of the disease which is common to the grape and apple. "Bitter rot" will not apply to the disease of the grape. "Anthracnose" is preëmpted, otherwise this might be used, as the fungus belongs to the same type as the one causing the grape anthracnose. The term "ripe rot" may answer the purpose in spite of its lack of euphony, as the disease attacks neither apples nor grapes until they begin to ripen.

The fungus seems to be slowly gaining a foothold on the grape, and in some parts of the country causes the grapes to rot after they are carried to the packing houses. Experiments have shown that it is easily controlled by fungicides, but there is great danger in the fact that it is already widespread on the apple, and wherever it is present on this fruit the grape is not secure from it.

EXPLANATION OF PLATES.

PLATE I.—HOLLYHOCK ANTHRACNOSE.

FIGS. 1 and 2. Diseased plants.
FIG. 3. Fruit of fungus.
FIG. 4. Spores: *a*, *c*, normal; *b*, germinating.

PLATE II.—ANTHRACNOSE OF COTTON.

FIGS. 1 and 2. Diseased bolls.
FIG. 3. Fruit of fungus.
FIG. 4. Successive stages in formation of spores in artificial cultures.
FIG. 5. Spores.

PLATE III.—RIPE ROT OF GRAPES AND APPLES.

FIG. 1. Diseased grapes.
FIG. 2. Diseased apple.
FIG. 3. Fruit of fungus.
FIG. 4. Spores.
FIG. 5. Germinating spores, producing secondary spores at *a*, *b*, *c*; *b*, secondary spore germinating.

HOLLYHOCK ANTHRACNOSE

ANTHRACNOSE OF COTTON BOLLS

RIPE ROT OF GRAPES AND APPLES,
(GLŒOSPORIUM FRUCTIGENUM, BERK.)

1.—Treated. TREATMENT OF PEAR LEAF-BLIGHT.—Bordeaux Mixture. 2.—Untreated.

1.—Treated. TREATMENT OF PEAR LEAF-BLIGHT 2.—U

REPORT OF THE CHIEF OF THE SEED DIVISION.

SIR: I have the honor to submit to you my report of the operations of this Division for the past year. This report consists mainly of the tables showing the distribution of seeds as to quantity, kind, and method of distribution, and also the quantity and kinds distributed to foreign countries, and of the condensed reports from correspondents.

A comparison between the table showing the quantity of seeds distributed and the reports from correspondents illustrates strikingly the force of the comment made in last year's report for this Division on the difficulty of making the average recipient of this bounty from the National Government comprehend that in return he is bound to report the results of the trial given to seeds sent him. The seeds sent abroad are usually sent in response to requests received through the representatives of these countries, or our own consuls resident therein, and are so sent most frequently in return for similar courtesies extended to this Department through the same channels.

A comparison of the distribution of seeds with that of the previous year will show an increase in the past year over the former by nearly a million of packages. The amount distributed also is far in excess of any previous years. It should be remembered, in considering this fact, that the appropriations for the year covered by the present report were just the same as for previous years, and that the larger amount of seed made available therefor was due entirely to a better system adopted in the purchase thereof. The plan adopted by your direction—the employment of a special agent who should personally visit various sections of the country, and inspect the places where the seeds were produced, as well as the seeds themselves—is to be credited with this great economy which has effected so great a saving in the aggregate cost of the seeds as to insure the purchase of this largely increased quantity without any increased expenditure. Moreover, this system of personal inspection has resulted in securing an improved quality of seed. Altogether, the outcome of last year's work in this direction is most gratifying, and fully confirms the most sanguine anticipations as to the results of this new departure.

It will be observed by reference to the first table that the aggregate distribution to State and county statistical agents and correspondents, and agricultural experiment stations, colleges, and associations, amounted to nearly half a million packages. As regards the statistical agents and correspondents, this distribution is in the nature of an acknowledgment of the valuable services rendered by these gentlemen gratuitously to the Statistical Division of this Department. As regards the distribution to the agricultural sta-

tions, colleges, and associations, it is obvious that as long as the present system of distribution continues, and the difficulties of obtaining reliable and prompt reports of results from the average recipient remain, we must rely mainly upon these institutions and associations for such careful trial of the seeds sent out, and such trustworthy reports as to results as will enable us to compile records of value to this Department in regard to the comparative value of different seeds and the special adaptability of certain varieties to particular localities. I shall endeavor during the coming year, with your approval, to enlarge this channel of distribution and to establish it upon a still more systematic basis.

I regret to have to emphasize in the present report the remarks made by my predecessor last year with reference to the inadequacy of the accommodations in the present building, both for the efficient performance of the duties involved by the distribution and for the proper handling and storage of the seeds as they are received and held for distribution. Even though there are no possibilities of remedying this state of affairs under the present conditions of the Department's building facilities, the results of our inadequate accommodations are so grave that I feel I should be remiss in the performance of my duty, were I not to call attention once more to the inconveniences from which this Division is suffering.

Respectfully submitted.

J. B. PECK,
Chief of the Seed Division.

Hon. J. M. RUSK,
Secretary.

CONDENSED REPORTS FROM CORRESPONDENTS.

ALABAMA.

Cotton.—The Champion Cluster is an excellent variety; it is long limbed, but has large bolls and a fine staple; it yielded 38 pounds of lint to 100 pounds of seed cotton. The Wimberly made from twenty to thirty bolls to the stock, had very superior lint, and seems well adapted to this section. Shine's Prolific matured early, and yielded about 300 pounds of seed cotton.

Sorghum.—The Red Liberian made a fine yield of very superior sirup.

Wheat.—Currell's Prolific grew rapidly and made a good crop, was not affected by rust, the kernel not being quite as large as the sample.

Vegetables.—The seeds received from the Department were all planted with gratifying results; the Early Surehead cabbage, the Early Puritan and the Trophy tomatoes are worthy of special commendation. The large Wethersfield onions were a success in all respects.

ARKANSAS.

Buckwheat.—The Japanese made a large yield, the flour being of very fine quality, and it is well adapted to this locality.

Cotton.—Wimberly's Improved is an excellent variety, with long lint and strong fiber, and is highly recommended for future planting.

Tobacco.—The Caboni is reported as an excellent variety for the northwestern section of this State.

Wheat.—The new Genesee made an excellent growth, the grain was entirely free from rust, and yielded better than the common kinds. The Rudy (bearded) is reported as making excellent flour, the grains and heads much larger than other varieties, and perfectly free from rust. The Velvet Chaff had very plump grains; one quart of seed yielded one half bushel of wheat.

Vegetables.—The Alaska pea is reported as being ten days earlier than other varieties and superior in all respects. The Edinburgh Beauty pea was very prolific, and very sweet. The Black Wax beans proved to be all that was claimed for them. Ely's King of the Earliest tomatoes were very early and prolific.

CALIFORNIA.

Sorghum.—The Honduras cane yielded nearly double the amount of sirup that the other varieties did.

Vegetables.—Carter's Stratagem peas grew well, were very early, and very prolific. Edmund's Imperial turnip beet was very sweet and succulent.

COLORADO.

Wheat.—The New Mediterranean has been very successfully raised in the south-eastern part of the State.

Vegetables.—The Eclipse beet did well, some specimens weighing 10 pounds and measuring 26 inches in circumference. The Yellow Danvers onions were uniform in size, and one of the best varieties for this climate. The Orange Cream pumpkins were excellent.

CONNECTICUT.

Buckwheat.—The Japanese did very well, yielding a third larger crop than the old varieties and was highly satisfactory.

Wheat.—The Velvet Chaff did exceedingly well. It came up nicely, stooled out well, and made a strong growth, reaching the height of 4½ feet. One quart of seed yielded one half bushel, weighing 31¾ pounds. It can be profitably grown in this section.

Vegetables.—The Pee & Kay corn was very early; the ears were large and very sweet. The Kidney Wax beans were of superior quality. Lane's Imperial beet made a large growth of fine vegetables, and they were very smooth and solid.

FLORIDA.

Clover.—The Japan germinated well, but was injured by protracted drought. The Luzerne also proved to be a fine variety.

Teosinte.—Grows rapidly, and was cut every twenty or twenty-five days during the season, and was more generally sought after by stock than the millet; but the seasons are too short to mature seed.

Vegetables.—The Citron melons were very fine; every seed germinated; each seed produced from five to ten good-sized melons. The Livingston tomatoes grew to perfection. The Osage muskmelons were very delicious, of good size, and delicate in flavor. The Miller Cream muskmelons were very fine in size and rich in flavor.

GEORGIA.

Cotton.—The Ellsworth proved to be a most remarkable and valuable variety. several stalks yielding as high as two hundred full-grown and well-developed bolls, The Wimberly is a long-limbed variety, the limbs coming out all around, having what is technically termed a well-balanced stalk; the lint was very good, and the seed seemed pure.

Clover.—The Japan and Sanfoin were both well adapted to this soil and climate; the Japan is a fine fattening plant for all kinds of stock.

Grasses.—The Texas Blue and the Rescue are both finely adapted to this section.

Vegetables.—The Dark Icing watermelon had a thin rind, crimson flesh, and was of excellent flavor, and was a decided success. The Black Wax beans can not be excelled for sweetness and tenderness.

ILLINOIS.

Corn.—The Piasa King was of vigorous growth and produced 40 bushels to the acre.

Oats.—The Improved American grew to the height of 4 feet and yielded nice, plump oats. The White Wonder stood the dry weather very well, the straw being about 2½ feet high, and the grain was sound and good.

Clover.—The Alfalfa stood the drought much better than other varieties grown under the same circumstances.

Wheat.—The reports upon the success of Velvet Chaff in this section are highly satisfactory; it was very early and yielded 22 bushels to the acre, 25 per cent better than other varieties which stood near it. It is ironclad in regard to standing hard winters. The Fulcaster is considered by some farmers as the best for this section,

the yield of the Velvet Chaff and the Fulcaster being about the same. Eight pounds of the seed of the Improved Rice sown yielded 90 pounds.

Vegetables.—Barr's Mammoth asparagus came up rapidly and made strong and vigorous plants. Lane's Improved sugar beet was very fine, the flavor being unsurpassed. Perry's Hybrid sweet corn had large ears and the grains were of good flavor.

INDIANA.

Oats.—The White Bonanza yielded well and was of good quality.

Teosinte.—This forage plant did well, and it will doubtless be largely planted next year.

Wheat.—The Velvet Chaff has proved to be one week earlier than other varieties, and makes a saving of 20 per cent of seed sown, the grain being somewhat small, but very plump and perfect, and weighing 61 pounds to the bushel. The Improved Rice gave perfect satisfaction. It grew strong and had an excellent berry, and its yield was 25 bushels to the acre, and it was pronounced by competent judges a superior wheat for milling. The Fulcaster was somewhat damaged by the cold weather of March, but yielded good, plump kernels.

Vegetables.—The Early Winningstadt cabbage, the Kidney Wax beans, the Long Green cucumbers, and the Yellow Danvers onions all germinated well, grew vigorously, and made satisfactory crops.

IOWA.

Corn.—The Minnesota King ripened early; the ears were well filled and sound; it is recommended to those wishing an early corn.

Tobacco.—The White Burley made a fine growth and formed good-sized leaves.

Sorghum.—The Kansas Orange sorghum was planted in rows 3⅔ feet apart one way and 1 foot the other; it averaged 11 feet in height, with large stalks, and made from it 97 gallons of light, clear molasses of excellent flavor and very thick.

Wheat.—The Velvet Chaff proved very productive, notwithstanding many discouraging circumstances; it stood the winter well and yielded more wheat and of better quality than any other winter wheat in this vicinity. Eight pounds of Hard Red Fyfe seed yielded at the rate of 15 bushels to the acre, the average yield of wheat in this section this year being only 11 to 12 bushels per acre. One quart of Martin's Amber was sown in 1887, which produced 76 pounds. It was sowed in 1888, and again in 1889, and it has done much better than any other variety tested, the miller pronouncing it a very superior milling wheat.

Vegetables.—The Alaska peas were hardy, made a good yield of excellent quality. The Red Crosby sweet corn produced abundantly and the ears were very sweet. The Improved Flageolet beans were an excellent variety and very prolific. The Pale Dun beans were very early, very prolific, and quite hardy. The Pee & Kay sweet corn was two weeks in advance of other varieties.

KANSAS.

Corn.—The Leaming produced at the rate of 45 bushels to the acre. The Prairie Queen made an immense growth, and was by far the best of eight varieties planted under the same circumstances. It yielded at the rate of 60 bushels per acre, and is a valuable corn for this latitude. The Piasa grew rapidly, with large stalks, was medium early, and the yield from 16 square rods was 11 bushels of shelled corn.

Oats.—The White Wonder proved to be an extra fine variety. One quart of seed yielded 1½ bushels of grain. The White Bonanza made a strong growth of large straw, and in a favorable season would no doubt be very productive.

Clover.—The Alfalfa made a good stand, does not freeze out through the winter, and will be a very profitable crop to grow.

Sorgum.—The Early Amber thrived finely, grew tall, with a smooth stalk, and made good sirup. The Early Orange made a good yield of sirup of excellent quality.

Wheat.—The Velvet Chaff stood the winter well; the berry was plump, round, and of good quality; 4 quarts of seed yielded 68 pounds of wheat. The Fulcaster was very fine in quality, and was considered a success. The New Genesee also was a success in northern Kansas.

Vegetables.—The Chiswick Red tomatoes did well. The Golden Perfection watermelons were a success. The Black Seeded Satisfaction lettuce was unsurpassed. The Kidney Wax bean was prolific and well adapted to this soil and climate.

KENTUCKY.

Wheat.—Currell's Prolific made a rapid growth, had long straw, and large grains 1 pound of seed yielded 31 pounds of wheat.

Vegetables.—The Chicago sweet corn was early, produced well, and was a very good variety. The Premium Flat Dutch cabbage was very early, made solid heads of fine flavor. The Red Top Strap Leaf turnips were large, crisp, and well flavored.

LOUISIANA.

Corn.—The Angel of Midnight is of dwarf growth, with very few leaves, and puts its ear out very close to the ground, and every sucker makes an ear; it does not shade the ground, and for that reason is a good variety to plant amongst cotton.

Cotton.—Shine's Early Prolific was excellent, and will do all that is claimed for it. Truitt's Improved succeeded well; the fruit was of large size, and it bolls well, making a hardy variety of cotton.

Vegetables.—Finney's Early watermelon was of medium size, pink flesh, remarkably sweet and tender; is very early, quite prolific, and in every respect a desirable melon. The Piasa corn was exceedingly fine for both field and table use; it grew large ears with large, tender grains.

MAINE.

Oats.—The Bonanza made a tall growth, stood up well, and yielded 3 pecks from 1 quart of seed.

Vegetables.—The Refugee bean was a great success. The Acme tomato was A No. 1. Carter's Stratagem pea was very prolific, sweet, and tender.

MARYLAND.

Corn.—The Angel of Midnight ripened from ten to fourteen days earlier than other varieties and yielded well.

Tobacco.—The Connecticut Seed Leaf was very satisfactory in quantity and quality; superior to other varieties experimented with.

Wheat.—Three quarts sown of New Genesee yielded 57½ pounds of excellent wheat. The Fulcaster gave perfect satisfaction. The Improved Rice and Velvet Chaff produced well, and the grain was excellent in quality.

MICHIGAN.

Corn.—The Early Minnesota King was wonderfully prolific, bearing from one to three ears on each stalk; it is a very desirable variety.

Oats.—Hargett's White yielded 73 pounds, of an excellent quality, from 2 quarts of seed. The White Wonder was unsurpassed in yield and weight; it is early and very productive; one half pound of seed harvested one half bushel of grain, weighing 37 pounds.

Sorghum.—The Planter's Pride made a good quality of sirup, and produced 140 gallons to the acre.

Wheat.—The Improved Rice was sown at the rate of one half bushel to the acre; the growth was healthy and strong, and 3 quarts of seed sown produced 1½ bushels of good, amber-colored grain. The Velvet Chaff stood up well, and made a first-class growth, and proved all that it was represented to be.

Vegetables.—The Early Cory sweet corn is a very choice variety. The White Tipped Scarlet radish did well. The Black Seeded Satisfaction lettuce headed like cabbage; the heads were large and compact, and almost white inside. Fottler's Brunswick cabbage was very fine; also the King of the Mammoths pumpkin was excellent. The Osage muskmelon and the Imperial beet took the first premium at the Benzie County Fair.

MINNESOTA.

Buckwheat.—The Japanese was sown at the rate of one half bushel per acre, and produced 25 bushels.

Clover.—The Alsike made excellent pasture, besides furnishing quite an amount of honey.

Wheat. The Hard Red Fyfe did well, and from 3 pounds of seed sown were

thrashed 24 pounds of good, plump wheat, superior in quality to other wheats tested.

Vegetables.—The Conical Head and Early Sugar Loaf cabbage are both excellent varieties. The Portland Hybrid sweet corn was very early and very satisfactory. The Alaska pea proved to be very desirable.

MISSISSIPPI.

Corn.—The Piasa King grew very rapidly, and bore from one to two ears on each stalk. It matured three weeks earlier than other varieties planted at the same time. It is an excellent variety for this section.

Cotton.—Farrell's Prolific, the Ellsworth, and the Truitt were very satisfactory.

Vegetables.—The Tomhannock lettuce is a fine variety; the Kidney Wax beans were extra fine and very prolific. The Philadelphia Butter lettuce was delicious, sweet, and tender to the last. Boyden's Wonder eggplant was a success.

MISSOURI.

Buckwheat.—The Japanese made a fine crop.

Wheat.—The Fulcaster yielded at the rate of 52 bushels to the acre of very fine plump grain. The Velvet Chaff made good heads and filled well. It stood the winter well, and will doubtless be a profitable variety for this section.

Vegetables.—Dewing's Improved Early turnip beet was of extra quality and very prolific. Crosby's sweet corn made a yield of 30 bushels per acre, and is a choice variety. The Orange carrot made a thrifty growth. The Black Seeded Satisfaction lettuce is a superior variety

NEBRASKA.

Corn.—The White Giant Normandy grew 12 feet high and yielded at the rate of 80 bushels per acre, but the seasons are too short here to mature seed.

Clover.—The Alfalfa made a growth of 15 inches in the midst of a severe drought. It stands the dry weather better than anything else we have tried.

Mangel Wurzel.—Far surpassed all expectations as regards size and quality.

Oats.—The White American Improved were pronounced to be the best for this climate and yielded 114 bushels to the acre; while the home oats in the same field only yielded 50 or 60 bushels to the acre.

Wheat.—One quart of Hard Red Fyfe yielded one half bushel and stood the drought well.

Vegetables.—The White Forcing radish was crisp, early, and of good quality. The Berkshire Beauty cabbage was the best of five varieties sown. The Horsford Market Garden pea was of first rate quality and yielded well. The Pee & Kay sweet corn, Dunlap's Prolific squash, and the Early Simpson lettuce, all did well, and were suited to this soil and climate.

NEW JERSEY.

Oats.—The White Bonanza grew to the height of 4 feet and had very fine heads.

Wheat.—Three fourths of a pound of New Genesee was sown on a plot 16 feet by 50, and it stooled out, and although partially destroyed by rabbits, yielded 50 pounds of nice grain.

Vegetables.—The Kentucky Field pumpkin yielded abundantly; the Golden Wax bean was very early; the Westerfield pickling cucumber was excellent in quality and very productive. Stowell's Evergreen sweet corn holds its rank as the largest and is of good quality.

NEW YORK.

Corn.—The Pride of the North was very prolific and excellent in quality.

Oats,—The White Wonder oats were strong growers, and yielded more abundantly than other varieties tested; they have a large grain and are well adapted to this climate.

Millet.—The German will do well with fair tillage and is a valuable plant. It is excellent to sow as a supplementary plant to make up deficiencies in the hay crop, and is nutritious, and is to be recommended for general culture.

Wheat.—The Velvet Chaff did not winter-kill, and produced well; it is a hardy variety.

Vegetables.—The St. Louis Market lettuce is spoken of very highly. The Prize Head lettuce proved to be a good variety. The Acme tomato, Philadelphia Butter lettuce, and the Early Cory corn all grew well and matured fine crops of excellent quality. The King of the Garden Lima bean was excellent.

NORTH CAROLINA.

Cotton.—Three fourths of an acre planted in the Ellsworth yielded 1,400 pounds of seed cotton, which ginned over one third. This is considered a good yield, and good judges pronounced it a very superior bolled cotton.

Clover.—The Japan came up very quickly and made an excellent grass.

Grasses.—The Timothy did well.

Sorghum.—The Red Liberian did well and yielded upward of 50 gallons of molasses, pronounced by judges to be a first-class article. Had a good mill been used doubtless the yield would have been 200 gallons.

Wheat.—Currell's Prolific was early and made a good yield. The New Genesee stood the winter well and yielded as fine wheat as any grown here.

Vegetables.—The Early Green Cluster cucumber germinated quickly and grew well. The New Jersey tomato is a rapid grower, very early, and produces fine fruit. The Eclipse beet is very prolific.

NORTH DAKOTA.

Oats.—Hargett's White germinated well and were not injured by several days of frost; the straw being very strong and stiff it stools wonderfully, producing as many as seven stalks from one kernel of seed.

Wheat.—The Red Fyfe yielded well, and produced first-class wheat in quality, hardiness, and color. It was very satisfactory.

Vegetables.—The Early Winningstadt cabbage was very superior, making large solid heads. The Philadelphia Butter lettuce and the Premium Flat Dutch cabbage both did well.

OHIO.

Corn.—The Pride of the North proved to be vigorous in growth, early, and productive.

Clover.—The Alfalfa and Japan clover were both very satisfactory and were not injured by the wet weather.

Forage.—The Vetch (Vicia Villosa) did not do well at first, and when other grasses were cut the last of June they were just beginning to blossom; but after that time they made a wonderful growth, and branched out near the ground, and the vines spread in every direction, until the whole was a complete mat of tangled vines; owing to the wet weather, the pods under the vines rotted, and did not ripen seeds. From its rank growth, it promises to be unequaled as a soiling plant.

Grasses.—The Johnson made a wonderful growth, and there is no doubt but that three crops could be cut in a season. The Orchard makes the finest appearance of all our grasses. It has a compact sod, and the blades are of a bright, green color, about 20 inches long; it held its own without assistance against weeds and wild grasses. The same is true of the Meadow Fescue and the Rye grass.

Wheat.—The New Genesee was sown at the rate of 6 pecks per acre. The habit of growth was superior to three other varieties in the same field, and it sent out more healthy and stronger shoots, and had covered the ground in advance of the others. The Rudy (bearded) yielded 68 pounds from one twenty-seventh of an acre; the grain was very large and plump. Four quarts of Velvet Chaff produced 70 quarts of fair quality of wheat, and it weighed 60 pounds to the bushel.

Vegetables.—The Roman Carmine turnip radish was very early, crisp, and neither wormy nor pithy, and retained its flavor much longer than other varieties. The Perpetual lettuce proved to be excellent. The Volunteer tomatoes were very early and productive, and of excellent quality.

PENNSYLVANIA.

Buckwheat.—The Japanese made a large yield, of a very fine quality of flour, and it is well adapted to this locality.

Oats.—The White Bonanza gave good results, the straw being heavy and stiff, and the heads were large and well filled, with large, plump kernels.

Wheat.—Three and one half pounds of Fulcaster were sown broadcast on one six-

teenth of an acre, and yielded 90 pounds of good wheat. The Improved Rice came up well, stood the winter, and 1½ quarts of seed yielded 14¼ pounds of very pretty plump grain.

Vegetables.—The Peach tomato produced handsome fruit, but of inferior quality. Moore's Concord sweet corn grew finely and was pronounced excellent in quality. The Flat Purple Top turnip is acknowledged by all as superior to other varieties.

SOUTH CAROLINA.

Cotton.—Shine's Early Prolific was a success and is considered a fine variety.

Forage.—The Unknown pea was very prolific.

Grasses.—The Texas Blue flourished well.

Vegetables.—The Bridgeport Late cabbage was early and made fine, solid heads. The Large Red Wethersfield onions did well. The Yellow Crook Neck squash bore abundantly.

SOUTH DAKOTA.

Oats.—One half bushel of White Wonder, sowed on three eighths of an acre, yielded 12 bushels of oats.

Wheat.—The Red Fyfe made a much better yield than other varieties tested. Two and a half pounds of seed yielded one half bushel of very good plump wheat.

Vegetables.—The Chicago Market sweet corn is very early, of good quality, and suitable for a northern climate. Dewing's Early Improved turnip beet is small, but very early and tender. The Everbearing pea did extremely well.

TENNESSEE.

Corn.—The Piasa King did remarkably well and was pronounced superior to other kinds.

Oats.—The White Wonder grew about 3½ feet high and matured very fine, plump grain, and made a much larger yield than other varieties sown under the same circumstances.

Wheat.—The Fulcaster has proved beyond question to be the wheat for this section of Tennessee. It harvested 380 per cent increase on the amount sown, and the straw was extraordinarily bright and strong.

Vegetables.—Henderson's Early Summer cabbage was a perfect success, as every seed germinated and made large compact heads. The Paris pickling onion was small, but exceedingly nice for pickling. The Fulton Market tomato was the best of twenty varieties.

TEXAS.

Corn.—The Piasa King did well, and yielded at the rate of 35 bushels to the acre. It is considered a superior variety.

Cotton.—The Jones's Improved is a very superior kind, and it yielded more to the acre and stood the vicissitudes of the weather better than other varieties. It has a fine staple, and large bolls. Truitt's Improved was very prolific, and excellent in yield and quality; it was early and very hardy.

Sorghum.—The Red Liberian proved a success in every variety of soil, in the mountain, valley, and river bottom districts, the joints being short, sweet, and the yield exceedingly good.

Vegetables.—The Cardinal tomato withstood an excess of rain, not cracking or rotting as other varieties. The Vandergrau cabbage was very early and excellent. The Rosy Gem radish was early and tender.

VIRGINIA.

Oats.—The White Wonder was very satisfactory.

Wheat.—The Improved Rice yielded 5 quarts to 1 sown. The Fulcaster was very healthy and vigorous, yielding 15 quarts to each 1 sown, of perfect, beautiful grain. It is a valuable wheat for this climate. The Velvet Chaff stooled well, made a very stiff straw, and the yield was 9 bushels per acre; the quality of the grain very good. The Rudy (bearded) is a fine variety, and, planted at the right time, will make an extraordinary yield.

Vegetables.—Vick's Early watermelon proved to be very fine; they were early and very prolific, some weighing from 15 to 20 pounds. The Alaska peas were early, prolific, and very satisfactory. The Champion of England peas were very productive and had large, well-filled pods. The Maud S peas are a superior variety.

WASHINGTON.

Wheat.—The Rudy (bearded) proved to be a good variety. The Improved Rice yielded 60 bushels to the acre, the grain being large and plump.

Vegetables.—Walker's Improved peas are all that can be desired in size, flavor, and productiveness. The Westerfield Chicago pickling cucumber yielded well; the fruit was of fine shape and size.

WEST VIRGINIA.

Sorghum.—The Early Orange made very fine sirup; three fourths of an acre sown yielded 91 gallons.

Wheat.—One quart of Fulcaster sown harvested 28 pounds of very fine grain, the other varieties only making half a crop.

Vegetables.—The First and Best peas were very early. The Chicago pickling cucumber and the Jersey tomato were both very good. The Deacon lettuce was very fine indeed.

WISCONSIN.

Buckwheat.—Eighteen pounds of seed of the Japanese made 808 pounds of nice, clean buckwheat, superior to any seed in this section. This is the testimony of a farmer of thirty-five years' experience.

Sorghum.—One quart of seed of the Red Amber Sugar Cane was sown on $1\frac{3}{8}$ acres and produced 54 gallons of extra fine sirup, pronounced by the manufacturer to be the best he had ever made.

Wheat.—The Velvet Chaff did well, withstood the winter, and is adapted to this locality. Seven pounds of seed planted produced 143 pounds of very plump grain of excellent quality.

Vegetables.— The New Peach tomato was very satisfactory. The Red Japan squash was of fair quality. The White Belgian carrot gave perfect satisfaction, also the Golden Dwarf celery. The Early Winningstadt cabbage had small, firm heads.

Kinds and quantities of seed issued from the Seed Division of the Department of Agriculture, under the general appropriation act of Congress, from July 1, 1889, *to June* 30, 1890.

Description of seeds.	Varieties.	Senators, Representatives, and Delegates in Congress.	County statistical correspondents.	State statistical agents.	Miscellaneous applicants.	Experiment stations and agricultural colleges and societies.	Total.
		Packages.	*Packages.*	*Packages.*	*Packages.*	*Packages.*	*Packages.*
Vegetable	208	3,972,232	109,680	39,080	480,592	118,107	4,719,691
Flower	204	349,219	141,600	225	140,965	900	632,909
Honey plant	2	....	....	....	149	....	149
Sunflower	1	....	....	....	372	....	372
Tobacco	10	60,930	....	....	4,033	57	65,020
Tree	8	....	....	....	160	....	160
FIELD SEEDS.							
Wheat	14	21,954	3,216	....	4,455	231	29,856
Oats	2	14,544	246	....	1,073	11,059	26,922
Corn	8	9,928	317	57	1,715	5	12,022
Barley	1	12	....	....	39	....	51
Buckwheat	1	267	482	57	2,688	8,370	11,864
Sorghum	14	830	239	....	1,134	29	2,232
Kaffir corn	1	....	....	....	70	5	75
Turnip	9	517	43,640	8,395	3,206	147	55,905
Sugar beet	5	1,739	223	....	2,865	1,094	5,921
Mangel-wurzel	1	53	126	....	315	20	514
Potatoes	1	4,834	....	....	251	2,380	7,465
Grass	17	12,774	407	....	3,608	309	17,098
Clover	4	331	212	....	1,183	7	1,733
Millet	1	14	....	57	206	5	282
Teosinte	1	48	174	....	290	20	532
TEXTILE.							
Cotton	6	9,552	449	....	4,217	225	14,443
Ramie	1	....	....	....	30	....	30
Grand total	....	4,459,778	301,011	47,871	653,616	142,970	5,605,246

Packages of seeds sent to foreign countries during the fiscal year 1889-'90.

Names of countries.	Vegetable.	Flower.	Corn.	Wheat.	Oats.	Buckwheat.	Millet.	Sugar beet.	Honey plant.	Forage plants.	Grass.	Clover.	Tobacco.	Potato eyes.	Sorghum.	Kaffir corn.	Broom corn.	Cotton.	Osage Orange.
Canada	115	130		1										1					
Mexico	390	30							2	10		2							
West Indies	43														15				
Guatemala	15																		
Honduras	480	35	25	25	25	25	25	25	40	28	105	75	25			1	25	25	
Venezuela	100	100																	
United States of Colombia	800		4	4	4	4	4												
Ecuador	145		10	20	10		10		5	5		35	15				5	5	
Chili	50	25	2		2													2	
Argentine Republic													16						
England	10	15											5						
France	20																		
Belgium			100		70										25				
Denmark	5	5																	
Sweden	10	10																	
Switzerland	50																		
Italy	20	20									2				12				48
Turkey	24		1		2	1		1			2								
Algeria															6				
Egypt			6												12				
Liberia	6																		
South Africa	14																		
India				4											36				
Java															15				
China										10		1							
Corea	185	10																	
Japan	23																		
Australia															18				
Fiji Islands	40	10											10						
	2,555	390	148	54	113	30	30	26	47	53	109	113	71	1	139	1	30	32	48

REPORT OF THE CHIEF OF THE DIVISION OF ILLUSTRATIONS.

SIR: I have the honor to submit my first report covering the few months that have elapsed since this Division was established under the appropriation act for the current fiscal year, July 14, 1890.

It will be interesting, I think, to accompany this first report with a brief review of the development of the work of illustration in this Department, which has culminated under your administration in the organization of a Division of Illustrations under my charge.

As long ago as 1878 the method which left the work of illustration to persons employed outside the Department was found to be extremely defective, and I was engaged to prepare the illustrations for the annual report, and to be available for such incidental work as might occasionally be required in connection with the several Divisions of the Department. These at that time not being numerous, one competent person sufficed to do all the work needed in the line of illustration, and for nearly two years I was the sole draftsman permanently employed in the Department. As the work increased beyond the capacity of any single person, however competent, it became necessary to engage other artists, but these being paid from the funds of the various Divisions needing their services were assigned to the forces of such Divisions. This arrangement, however, was found to have many defects and it was impossible under these conditions to systematize the work. There were times when some of these artists were overworked, while others had time to spare. Again, it was impossible to so divide the work as to enable each to work to the best advantage, some being assigned to work which others could have performed more efficiently than they, and *vice versa*, while, and this was the chief objection, there was no one responsible head charged with the duty of superintending all the work and held responsible for its faithful execution. These difficulties were apparent to you from the very beginning of your administration, and hence the organization by your direction of a Division of Illustrations which you were good enough to place under my charge.

As thus organized, the Division consists of one chief, eight assistant draftsmen (one such place being at this writing vacant), and three wood engravers. The work of the Division is scientific, requiring great skill and experience; and being from nature, and often from specimens in a dried or injured condition, frequently calls for the greatest ingenuity on the part of the artists. Moreover, many of the specimens are so minute as to require the magnifying glasses or the microscope in elucidating the details, and our draftsmen, therefore, must be familiar with the handling of these instruments. The work of the Division consists in drawing illustrations on wood for engraving by the xylographers, or on paper with pen and ink, or painting them in water colors, the illustrations made by the two latter methods being reproduced outside of the Department by lithography, or photo-

engraving, or by "process work." Many drawings, paintings, and sketches have to be prepared in the Division which are not intended for publication, but for the purpose of fixing graphically some interesting phase in the development or life history of objects from the plant or animal kingdom.

I have ventured to thus present to your consideration in detail the exacting character of the work required of this Division in order that the necessity for assistants of the highest order in this department of the work might be thoroughly understood, and in view of the manner in which the work is now being performed by the force actually at my disposal I beg to respectfully suggest that their efforts be recognized if possible by the application of a more liberal scale of remuneration.

The following is a record of the work performed under my charge for a period of something less than six months, showing the several Divisions for which the work has been executed:

Entomology, 32 plates, aggregating 160 figures, pen and ink; Botany, 12 plates, partly on wood, partly pen and ink work; Chemistry, 13 plates, illustrating new chemical apparatus, pen and ink; Forestry, 6 plates, on wood, double size, with two maps; Microscopy, 57 plates, mostly water colors; Ornithology, 17 plates, pen and ink; Animal Industry, 50 plates, containing more than 200 figures, mostly microscopical; Vegetable Pathology, 40 plates of over 150 figures, in pen and ink, and in color. Of engravings by the xylographers of the Division: Botany, 7 plates; Chemistry, 1 plate; Forestry, 6 plates, double size; Entomology, 1 plate; Irrigation Inquiry, 1 plate.

A considerable amount of other work has been begun and partly completed. As most of the plates contain from five to ten figures, and as the period in question covers that during which the annual leaves of absence of the force of this Division occurred the, amount of work must be regarded as highly creditable to the force engaged.

In this connection I consider it my duty to submit to your consideration the fact that the only rooms which it was found possible to assign to this Division, located in the attic of the main building directly under the roof, are in many respects unsuited to the work required of us, while their very high temperature during the summer months (on several days 102° to 104° Fahr.) renders the work of this Division extremely onerous.

In conclusion, allow me to say that many of the illustrations of this Department have gained an enviable reputation even in European scientific circles in return for our efforts to send out only such work as will be a credit to this Department. It has not unfrequently happened, however, that while the original drawings or paintings had been made with the utmost care and accuracy and were in every respect creditable, the reproduction done outside the Department by some of the methods indicated above has been quite unsatisfactory and inferior.

I would suggest that if some way could be devised by which the supervision of the chief of the Division could be extended to the work of illustration up to and including the actual printing of the plates such a course would, I am convinced, secure the reproduction of our work in the best manner and as economically as at present.

Respectfully submitted.

GEORGE MARX,
Chief of the Division of Illustrations.

Hon. J. M. RUSK,
Secretary.

REPORT OF THE CHIEF OF THE DIVISION OF RECORDS AND EDITING.

SIR: I have the honor to present herewith a report upon the work of this Division during its first half year, together with certain recommendations which aim to extend the usefulness of the publications of this Department.

Very respectfully,

GEO. WM. HILL,
Chief of the Division of Records and Editing.

Hon. J. M. RUSK,
Secretary.

WORK OF THE DIVISION.

The Division of Records and Editing was practically called into existence by my appointment on the staff of the Statistician in July, 1889, and the work which I then undertook did not differ materially from that now carried on by the Division as at present organized under the act of appropriation of July 14, 1890, except in being restricted necessarily before that date by the want of sufficient clerical force from undertaking all that was contemplated as the work of the new Division. The organization of the Division was undertaken immediately upon the passage of the act of appropriation, and the positions provided thereby were duly filled by your appointments in compliance with the law regulating the Civil Service.

The work of this Division should, so far as its responsible head is concerned, supply the place of the "reader" of a publishing house, to whom all work for publication is submitted, and whose report to the chief is made the basis of the latter's conclusion as to publication. This is rendered necessary, not only to enable the chief to assume due responsibility of what is published by his authority, but to enable him to fairly and judiciously assign the printing fund between the several Divisions of the Department. It must also afford to the Division chiefs who supply the matter all the facilities of a publishing house, supervising the work from the moment it leaves the hands of the author until the work appears in complete form ready for distribution.

By fulfilling adequately these two lines of duty it will certainly not only relieve the Secretary and the Division chiefs of a large amount of work, but, in the hands of competent persons of the right practical experience in the work of publication and printing, it will necessarily accomplish the work better and much more economically. The amount of the printing fund of the Department, though inade-

quate to the publication work required, is yet so large a sum as to make it a matter of economy to place its administration in practical hands.

It is safe to say that in no private business would it be deemed wise to allow the expenditure of $40,000 annually on any line of work without placing it under some responsible and experienced head.

The character of a bulletin must determine the extent of circulation, and hence the number of copies required. The occasional reproduction in another form of a portion of some bulletin can sometimes be economically and advantageously substituted for an increased edition of the original publication; the complete preparation of a work in proper form, ready for the printer's hand, is a saving of time and money, and in a variety of ways this Division, if managed as it ought to be, can and should aid in securing to the publication work of this Department—work that grows in importance every day—a full measure of efficiency and economy.

There could be no better evidence of the possible efficiency of the new Division than that afforded by the subjoined list, which represents the publication work of the Department for the past twelve months.

THE PUBLICATIONS OF THE DEPARTMENT.

The editing of all the bulletins issued by the Department from its several divisions, and the conferences entailed in the course of my duties with the chiefs of the several divisions, have resulted in some conclusions as to the publications of the Department, which I have now the honor to lay before you. The first element entitled to our consideration in the preparation of the Department publications must be the constituents whom the Department is specially designed to serve. The value of the Department must necessarily be measured in a large degree by the amount of valuable practical information which it is enabled to impart to farmers in regard to their business, and in the aid which it can thus afford them in solving the problems with which they find themselves confronted. At the same time there is an obvious necessity for the preservation in printed form of a record of all scientific work done in the various divisions of the Department, whether its immediate results have or have not any direct interest for the practical farmer. The Department owes something to the student and the scientist, as well as to the farmers, and it owes this much at least to its own workers and to those who are to succeed them, namely, to place in their hands a complete detailed record of all the technical and scientific work carried on in the several divisions, whatever the results thereof may have been.

It is obvious, then, that we are confronted at the outset with the necessity for at least two classes of publications—one consisting simply of records of scientific work; the other presenting results of practical value to the farmers themselves. The first being of value chiefly to agricultural students, scientific men, and the workers in the Department and in the agricultural colleges and experiment stations of the country, can be issued in comparatively limited editions; the others according to their character in larger editions.

The great increase in the number of divisions preparing matter for publication, and the dual character of most of them—combining administrative duties with scientific research—have resulted in the necessity for important modifications in the character and scope of

the Annual Report of the Department. Your own declaration approving "the frequent issue of special bulletins from the various divisions relating to the work undertaken by them instead of awaiting the issue of the Annual Report, already too bulky for the purpose for which I conceive it to be designed," suggests in the main the character of the modifications to which I refer; and the necessity for such modifications was amply confirmed when, after consultation with the various chiefs of divisions in anticipation of the publication of the Annual Report of the Department for 1889, it was found that space was desired which would have resulted in a bulky volume of not far from 1,500 pages, whereas the Report as actually published consisted of less than 600 pages. It is evident that the time has come when the Annual Report of the Department must offer to each chief of Division merely an opportunity for a business report to his chief of the work actually performed in the Division which he superintends, for a general review of the field of economic agriculture assigned to his division, and for presenting suggestions and plans for increasing the efficiency and extending the benefits of his work. At the same time a great extension is called for in the line of publications in the form of special bulletins. It should not be forgotten in this connection that notwithstanding the increase in the number of divisions, the great extension of the general scope of work assigned to the Department, no increase has been made in the last few years in the amount of the printing fund, while on the other hand a considerable reduction has been made in the number of copies of the Annual Report remaining at the disposal of the Department. In anticipation of a considerable increase in the number of bulletins, and a considerable increase in many cases of the number of copies issued, as, for instance, in the case of the monthly crop report, which, being practically a monthly review of the condition of agriculture throughout the world, should be far more extensively distributed than it is; and in view also of the necessity for increasing the number of the bulletins referred to as "Farmers' Bulletins," it seems quite impossible that even with all the discrimination exercised in the distribution, the Department can accomplish the least that is expected of it in the line of publication with an appropriation of less than $60,000.

In the meantime, in view of the large number of divisions engaged in preparing matter for publication, and the desirability of an equitable apportionment of the printing fund, it would seem as though some method might be devised which will give to every Division a fair share of the publication fund during the year in proportion to the relative importance of the matter which each has to present. To effect this, it would be necessary that each divisional chief should submit at the beginning of the fiscal year a table of matter on hand already prepared for publication, and also a list of proposed publications, the preparation of which could be completed in time to bring the publication within the current fiscal year. In this way the relative value of the proposed publications could be properly estimated; a suitable allotment of the printing fund arranged for by which justice should be done to every Division; and when the fund was found insufficient for all the publication work contemplated, that which seemed to promise the greatest general benefit could be selected. At present, it not unfrequently happens that a considerable amount of work is done in the preparation of a bulletin for publication, only to find out when the work is done, naturally to the great disappointment of

the chief of the Division under whom it has been prepared, that there is no fund available to print it.

The limited amount of the printing fund available for the publications of the Department outside of the Annual Report has necessitated great economy in the work of publication, sometimes limiting the number and editions, so that valuable bulletins are soon out of print, and at other times compelling the undue postponement of bulletins containing information which should promptly be made available, and in a few cases entailing the abandonment of a publication after a considerable amount of work had already been done in its preparation. Considerable economy has been and must continue to be exercised in the method of distribution, and the prevalent idea existing in the country that the bulletins of the Department are published in unlimited numbers, and that the easiest way to get any special one is to simply request that *all* the bulletins issued by the Department be sent regularly, permitting the two or three of practical use to the writer to be selected and the rest to be consigned to the garret, must be done away with. In fact, at present the varied character of the work carried on in the Department and the tendency of the farmers themselves to specialize, makes it well-nigh impossible for any one individual to be profited by all the bulletins issued.

In the effort, therefore, to husband our resources, one of the first things to be done is to carefully discriminate in the distribution of the various bulletins of the Department, and simple requests that the writer may receive all the bulletins issued by the Department, without any explanation, should be entirely ignored. Another movement in the line of economy must be the frequent substitution for more expensive bulletins, of short treatises or tracts on some particular subject of special interest to the farmers generally, or to the farmers in some particular locality. Such were the special bulletins on "The Horn Fly," on "Potato Rot" and "Peach Blight," "Inoculation for Hog Cholera," "The Beef Supply," "The Hollyhock Disease," "The What and Why of the Experiment Stations," and "The Work of the Experiment Stations," the last two having aggregated a circulation of 200,000, and having been given the suggestive title of "Farmers' Bulletins." The necessity for bulletins of this kind arises from time to time in all the divisions of the Department, and seems for many practical as well as economical reasons to be worthy of the greatest encouragement, and I would venture to suggest that all the bulletins of this character hereafter be issued, each as one of a Department series, to be known as "Farmers' Bulletins," and to be numbered consecutively, and not as a special series of the Division from which it emanates.

In some cases it has been deemed desirable to issue bulletins of a periodical character in monthly or quarterly parts. While no doubt much may be said in favor of such a method, it is in my opinion open to certain grave objections, likely to grow stronger as the work progresses, and sufficient to overcome all the arguments offered in its favor. In the first place, the Department is not a publishing house, and it is essential that the occasion of a publication should be not the recurrence of any particular date or the lapse of any particular period, but the possession of facts or information worth making public. Indeed, in pursuance of this idea, the regular periodicity of these serial publications in the Department must be and in some cases has been practically abandoned. There is a tendency, however, with all such serials to approach some hard and fast

rule as to number of pages, etc., which ought to have no part whatever in regard to the publications of the Department. Whether a bulletin is to be ten pages or fifty should depend not upon looks or upon the relative number of pages in the preceding number, but whether the valuable information ready to be given out can best be presented in ten pages or more. Furthermore, from what has been said already in regard to the varied character and the several classes of bulletins which seem to be necessary to meet all requirements, it is obvious that serial publications containing a little of each sort entail a large waste of matter in distribution, for it would be well-nigh impossible for any Division to issue a satisfactory periodical bulletin consisting exclusively of matter appropriate to one or the other of the three classes of bulletins indicated.

The arguments which have seemed sufficient to establish the necessity for the publication in some special form of the detailed scientific work of the several divisions of the Department have so far been mostly advanced in favor of the issue of periodicals by the several divisions. While the arguments themselves are well founded, I think, for reasons stated above, that the conclusions are not satisfactory. Taking, however, the arguments as to the necessity of a complete record of the scientific work done in the Department, and the objections that unquestionably obtain against the adoption of separate serial publications by the various scientific divisions, it would be possible, perhaps, to satisfy the first and to meet the second by adopting the serial form for a Department publication of a technical character, to which all the divisions would have access, and which should be practically a record or review of the scientific work of the several divisions of the Department, which would serve as a suitable book of reference for such work, not only for those who will carry it on in the future, but to the students and others engaged in the work of agricultural science. Such a publication, under certain limitations, ought, it seems to me, to answer a very useful purpose and satisfy the requirements of the various scientific divisions as well as the natural demands of those engaged in analogous work.

A glance at the subjoined list of publications, and the fact that since 1885 no general index has been kept of the publications of the Department, point very strongly to the necessity of beginning such important work before it becomes an overwhelmingly tedious and irksome task. Indeed, in view of the vast importance of much of the work undertaken in the several divisions, and inasmuch as some of the most important bulletins have, as has already been stated, gone out of print, it seems to me worth while to consider whether work akin to that carried on in the office of Experiment Stations with reference to the publications of such Stations, in accordance with the law indicating the relation between the Stations and the Department, should not be undertaken with reference to the publications of the Department itself.

For fear of causing misapprehension in reference to the suggestions contained herein as to increasing the number of special bulletins and the different classes of bulletins contemplated, it may be well that I should here emphasize my perfect understanding that the publication work of this Department must be carried out in full compliance with the general policy which demands that the work of a Government institution be directed to aid and supplement the efforts of, and not to compete with, private enterprise.

I beg leave to direct your special attention to the subjoined list of

the publications of the Department for the year. It presents, I think, a very striking exhibit of the activity of work in every Division of the Department under your charge, though inadequate in its testimony, inasmuch as several publications practically ready have had to be withheld, owing to the insufficiency of the printing fund.

PUBLICATIONS OF THE YEAR.

In the list subjoined the summary of publications contained in your last Annual Report is continued and brought down to the close of the current year. To supply a need repeatedly suggested by the correspondence of the Department, the character of each bulletin is briefly indicated in cases where this is not accomplished by the title alone. Circulars are not mentioned below, unless they have served to distribute information. Such as have been used to facilitate inquiry, though occasionally given a document number, may be classed more properly as correspondence, being, for the most part, blanks which are mailed to correspondents to be filled out and returned. The fact that during the year upwards of 400,000 have been mailed from the Division of Statistics alone will indicate the extent to which their use is found necessary. The size of bulletins mentioned below is uniformly octavo unless otherwise specified; the date assigned to each is intended to represent the date of its actual receipt for distribution from this Department.

At this writing all bulletins of the year are available for distribution to public libraries, and copies of nearly all can be furnished to individual applicants. Owing to the wide demand for the Report of 1889, however, the supply allotted by law to this Department is now exhausted, and persons applying for the publication will necessarily have to be referred hereafter to their Representatives in Congress. (See page 2.) The annual reports of the Bureau of Animal Industry, also, are largely retained by Congress.

OFFICE OF THE SECRETARY.

Report of the Secretary of Agriculture for 1889. With plates, wood cuts, and index. June, 1890, pp. 560	400,000
Report of the Secretary of Agriculture for 1890. (Preliminary.) November, 1890, pp. 52	5,000

BUREAU OF ANIMAL INDUSTRY.

Fourth and Fifth Annual Reports of the Bureau of Animal Industry for the years 1887 and 1888, with plates. March, 1890, pp. 510	50,000
Report on the Beef Supply of the United States, and the Export Trade in Animals and Meat Products, by Dr. D. E. Salmon. (Advance sheets from Report of the Secretary of Agriculture for 1889.) March, 1890, pp. 15	10,000
Report on Inoculation as a Preventive of Swine Diseases. (Advance sheets from Annual Report of the Secretary of Agriculture for 1889.) March, 1890, pp. 10	10,000
Proceedings of an Interstate Convention of Cattlemen, held at Fort Worth, Texas, March 11, 12, and 13, 1890. May, 1890, pp. 102	5,000
The Animal Parasites of Sheep, by Cooper Curtice, D. V. S., M. D., with plates. July, 1890, pp. 222	15,000
Report of the Chief of the Bureau of Animal Industry for the year 1889. Author's edition. (From the Report of the Secretary of Agriculture for 1889.) August, 1890, pp. 49–110	500
Special Report on Diseases of the Horse. (In press.)	20,000

DIVISION OF BOTANY.

The Agricultural Grasses and Forage Plants of the United States and such Foreign Kinds as have been introduced. By Dr. George Vasey, Botanist. With an appendix on the chemical composition of grasses, and a glossary of terms used in describing grasses. New, revised, and enlarged edition, with 114 plates. January, 1890, pp. 148	10,000
Grasses of the Southwest. Plates and Descriptions of the Grasses of the Desert Region of Western Texas, New Mexico, Arizona, and Southern California. Part 1. By Dr. George Vasey, Botanist, Department of of Agriculture. October, 1890, pp. 108 (7½ by 11½ inches)	5,000
Contributions from the U. S. National Herbarium, No. 1. (Lists of plants collected in Southern California, and at Lagoon Head, Cedros Island, San Benito Island, Guadaloupe Island, and the head of the Gulf of California.) June, 1890, pp. 28	2,000
Contributions from the U. S. National Herbarium, No. 2. (A collection of plants made in Texas, in the region of the Rio Grande.) July, 1890, pp. 29–62	2,000
Contributions from the U. S. National Herbarium, No. 3. (A list of plants collected in Lower California and Western Mexico.) With plate. November, 1890, pp. 63–90	2,000
Report of the Botanist for the year 1889. Author's edition, with plates. (From the Report of the Secretary of Agriculture for 1889.) August, 1890, pp. 377–396	1,000

DIVISION OF CHEMISTRY.

Chemical Bulletin No. 24. Proceedings of the Sixth Annual Convention of the Association of Official Agricultural Chemists, held at the U. S. Department of Agriculture, September 10, 11, and 12, 1889. Methods of Analysis of Commercial Fertilizers, Cattle Foods, Dairy Products, and Fermented Liquors. Edited by Harvey W. Wiley, Secretary of the Association. March, 1890, pp. 235	2,500
Chemical Bulletin No. 25. A Popular Treatise on the Extent and Character of Food Adulterations. By Alexander J. Wedderburn, Special Agent. February, 1890, pp. 61	10,000
Chemical Bulletin No. 26. Record of Experiments in the Production of Sugar from Sorghum in 1889 at Cedar Falls, Iowa; Rio Grande, New Jersey; Morrisville, Virginia; Kenner, Louisiana; College Station, Maryland; and Conway Springs, Attica, Medicine Lodge, Ness City, Liberal, Arkalon, Meade, Minneola, and Sterling, Kansas. By H. W. Wiley, Chemist. April, 1890, pp. 112	10,000
Chemical Bulletin No. 27. The Sugar Beet Industry, Culture of the Sugar Beet and Manufacture of Beet Sugar. By H. W. Wiley, Chemist. With plates, wood cuts, and map. September, 1890, pp. 262	10,000
Chemical Bulletin No. 28. Proceedings of the Seventh Annual Convention of the Association of Official Agricultural Chemists, etc. (In press.)	2,500
Report of the Chemist for the year 1889. (From the Report of the Secretary of Agriculture for 1889.) August, 1890, pp. 135–190	500

DIVISION OF ENTOMOLOGY.

The Horn Fly (*Hæmatobia serrata*), being an account of its Life History and the Means to be used against it. By C. V. Riley and L. O. Howard. (Reprinted from Insect Life, Vol. 2, No. 4.) December, 1889, pp. 93–103.	2,000
Entomological Bulletin No. 20. The Root-Knot Disease of the Peach, Orange, and other Plants in Florida, due to the Work of Anguillula. By J. C. Neal, Ph. D., under the direction of the Entomologist. With plates. October, 1889, pp. 31	5,000
Entomological Bulletin, No. 21. Report of a Trip to Australia to Investigate the Natural Enemies of the Fluted Scale, by Albert Koebele, under the direction of the Entomologist. With illustrations. March, 1890, pp. 32.	3,000
Entomological Bulletin, No. 22. Reports of Observations and Experiments in the Practical Work of the Division, made under the direction of the Entomologist. With illustrations. June, 1890, pp. 110	8,000

Insect Life. (Devoted to the economy and life habits of insects, especially in their relations to agriculture, and edited by the Entomologist and his assistants. With illustrations.)

Vol. 2, No. 5. December, 1889, pp. 125–162 5,000
Vol. 2, No. 6. January, 1890, pp. 163–197 5,000
Vol. 2, Nos. 7 and 8. February, 1890, pp. 198–262 5,000
Vol. 2, No. 9. March, 1890, pp. 263–292 5,000
Vol. 2, No. 10. May, 1890, pp. 293–334 5,000
Vol. 2, Nos. 11 and 12. July, 1890, pp. 335–390 5,000
Vol. 3, No. 1. August, 1890, pp. 42. With table of contents and index for Vol. 2 5,000
Vol. 3, No. 2. October, 1890, pp. 43–88 5,000
Vol. 3, No. 3. November, 1890, pp. 89–130 5,000
Vol. 3, No. 4. December, 1890, pp. 131–178 5,000

Report of the Entomologist for the year 1889. Author's edition. (From the Report of the Secretary of Agriculture for 1889.) August, 1890, pp. 331–361. With index 1,000

Insecticides and Means of Applying them to Shade and Forest Trees. By C. V. Riley. Author's edition. (Reprinted from the Fifth Report of the U. S. Entomological Commission.) February, 1890, pp. 31–47 200

Insects affecting the Hackberry (various species of Celtis), by C. V. Riley. Author's edition. (Reprinted from the Fifth Report of the U. S. Entomological Commission.) October, 1890, pp. 601–622 200

OFFICE OF EXPERIMENT STATIONS.

Experiment Station Record. (A condensed record of the contents of the bulletins issued by the Agricultural Experiment Stations of the United States.)

Vol. 1, No. 1. November, 1889, pp. 56 5,000
Vol. 1, No. 2. March, 1890, pp. 57–116 5,000
Vol. 1, No. 3. May, 1890, pp. 117–174 5,000
Vol. 1, No. 4. May, 1890, pp. 175–244 5,000
Vol. 1, No. 5. June, 1890, pp. 245–308 5,000
Vol. 1, No. 6. August, 1890, pp. 309–358. With index 5,000
Vol. 2, No. 1. August, 1890, pp. 40 5,000
Vol. 2, No. 2. September, 1890, pp. 41–88 5,000
Vol. 2, No. 3. October, 1890, pp. 89–138 5,000
Vol. 2, No. 4. November, 1890, pp. 139–184 5,000
Vol. 2, No. 5. December, 1890, pp. 185–264 5,000

Experiment Station Bulletin, No. 4. List of Horticulturists of the Agricultural Experiment Stations in the United States, with an outline of the work in horticulture at the several Stations. By W. B. Alwood. January, 1890, pp. 27 5,000

Experiment Station Bulletin, No. 5. Lists of the Agricultural Experiment Stations and Agricultural Schools and Colleges in the United States. May, 1890, pp. 67 5,000

Experiment Station Bulletin, No. 6. List of Botanists of the Agricultural Experiment Stations in the United States, with an outline of the work in botany at the several Stations. June, 1890, pp. 23 5,000

Miscellaneous Bulletin, No. 2. Proceedings of the Third Annual Convention of the Association of American Agricultural Colleges and Experiment Stations, held at Washington, D. C., November 12, 13, 14, and 15, 1889. July, 1890, pp. 142 4,000

Farmers' Bulletin, No. 2. The Work of the Agricultural Experiment Stations. (Better cows; fibrin in milk; bacteria in milk; silos and silage; alfalfa; field experiments with fertilizers.) June, 1890, pp. 16 150,000

Report of the Director of the Office of Experiment Stations for the year 1889. Author's edition. (From the Report of the Secretary of Agriculture for 1889.) August, 1890, pp. 485–544. With index 1,000

DIVISION OF FORESTRY.

Forestry Bulletin, No. 4. Report on the Substitution of Metal for Wood in Railroad Ties. By E. E. Russell Tratman, C. E. Together with a Discussion on Practicable Economies in the Use of Wood for Railway Purposes. By B. E. Fernow, Chief of the Division of Forestry. With plates and index. August, 1890, pp. 363 5,00

Report of the Chief of the Forestry Division for the year 1889. Author's edition. (From the Annual Report of the Secretary of Agriculture.) August, 1890, pp. 273–330 1,000

DIVISION OF MICROSCOPY.

Report of the Microscopist for the year 1889. Author's edition. (From the Report of the Secretary of Agriculture for 1889.) With plates. August, 1890, pp. 191–200 500

DIVISION OF ORNITHOLOGY AND MAMMALOGY.

North American Fauna. (A record of such results of the work of this Division as are of use mainly to those engaged in scientific research.) No. 1. Revision of the North American Pocket Mice. With plates. October, 1889, pp. 36 5,000

North American Fauna, No. 2. Description of fourteen new species and one new genus of North American Mammals. With plates and index. October, 1889. pp. 52 5,000

North American Fauna, No. 3. Results of a Biological Survey of the San Francisco Mountain Region and Desert of the Little Colorado, Arizona. With plates, maps, and index. September, 1890, pp. 136 5,000

North American Fauna, No. 4. Descriptions of twenty-six new species of North American Mammals. With plates and index. October, 1890, pp. 60 5,000

Annotated List of Reptiles and Batrachians collected by Dr. C. Hart Merriam and Vernon Bailey on the San Francisco Mountain Plateau and Desert of the Little Colorado, Arizona, with descriptions of new species. By Leonhard Stejneger. Author's edition. (Reprinted from North American Fauna, No. 3.) October, 1890, pp. 103–123 100

Report of the Ornithologist and Mammalogist for the year 1889. Author's edition. (From the Report of the Secretary of Agriculture for 1889.) With plates. August, 1890, pp. 363–376 1,000

DIVISION OF POMOLOGY

Pomological Bulletin, No. 3. Classification and Generic Synopsis of the Wild Grapes of North America. By T. V. Munson. October, 1890, pp. 14 6,000

Report of the Pomologist for the year 1889. Author's edition. (From the Report of the Secretary of Agriculture for 1889.) With plates. August, 1890, pp. 433–452 500

DIVISION OF STATISTICS.

Statistical Report, No. 68. Report on Yield of Crops per Acre and on Freight Rates of Transportation Companies. (Estimated yields of corn, potatoes, buckwheat, sorghum, tobacco, and hay.) November, 1889, pp. 439–484 19,000

Statistical Report, No. 69. Report on the Crops of the Year and on Freight Rates of Transportation Companies. (Prices of farm products, area and condition of fall sowing of wheat and rye, etc.) January, 1890, pp. 485–548 .... 19 000

Statistical Report, No. 70. Report upon the Numbers and Values of Farm Animals and on Freight Rates of Transportation Companies. (Including cotton returns, our foreign trade in dairy products, and European Crop Report.) February, 1890, pp. 64 19,000

Statistical Report, No. 71. Report on Distribution and Consumption of Corn and Wheat and on Freight Rates of Transportation Companies. March, 1890, pp. 65–116 19,000

Statistical Report, No. 72. Report of the Condition of Winter Grain, the Condition of Farm Animals, and on Freight Rates of Transportation Companies. (Including European crop report for April.) April, 1890, pp. 117–174 18,000

Statistical Report, No. 73. Report of the Condition of Winter Grain, the Progress of Cotton Planting, and Wages of Farm Labor; also on the Freight Rates of Transportation Companies. (Including report on farm wages, sugar production in Europe, European Crop Report, and United States Consular Reports.) May, 1890, pp. 175–230 18,000

Statistical Report, No. 74. Report on the Acreage of Wheat and Cotton and Condition of Cereal Crops and on Freight Rates of Transportation Companies. (Including report on cotton production and trade of the world, domestic and foreign wools, course of agricultural prices, farmers' milling companies, and European Crop Reports.) June, 1890, pp. 231-310	18,000
Statistical Report, No. 75. Report on the Area of Corn, Potatoes, and Tobacco and Condition of Growing Crops and on Freight Rates of Transportation Companies. (Including report on Statistics of Mexico, European crop prospects, and notes on foreign agriculture.) July, 1890, pp. 311-374	18,000
Statistical Report, No. 76. Report on the Condition of Growing Crops and on Freight Rates of Transportation Companies. (Reports on Statistics of Canada, Argentine Statistics, European crops, and the Indian wheat crop.) August, 1890, pp. 375-430	18,000
Statistical Report, No. 77. Report on Condition of Crops in America and Europe and on Freight Rates of Transportation Companies. (Including a report on tariffs of South America and a statistical review of Venezuela.) September, 1890, pp. 431-494	18,000
Statistical Report, No. 78. Report on Condition of Crops, Yield of Grain per acre, and on Freight Rates of Transportation Companies. (Including reports on the crop year in California and Colorado, and prices of wheat in 1890.) October, 1890, pp. 495-542	18,000
Statistical Report, No. 79. Report on Yield of Crops per Acre and on Freight Rates of Transportation Companies. (Including reports on a decade of wheat exports, statistics of Colombia, small holdings and allotments in Great Britain, and the French agricultural syndicates.) November, 1890, pp. 543-590	18,000
Statistical Report, No. 80. Report on the Crops of the Year and on Freight Rates of Transportation Companies. (Including reports on New York Dairymen's Association meeting, financial condition of California farmers, peanut production, European Crop Report for December, and Belgian crops, 1889 and 1890.) January, 1891, pp. 591-652	18,000
Miscellaneous Report, No. 1. (New Series.) A Report on Flax, Hemp, Ramie, and Jute, with considerations upon flax and hemp culture in Europe, a report on the ramie machine trials of 1889 in Paris, and present status of fiber industries in the United States. By Charles Richards Dodge, Special Agent. With illustrations and index. April, 1890, pp. 104	10,000
Synopsis of the monthly reports of the Statistician (a brief recapitulation of the returns of statistical correspondents, intended for prompt and wide circulation in advance of the regular Monthly Crop Report from which it is condensed):	
March Report. March, 1890, pp. 4	20,000
April Report. April, 1890, pp. 4	80,000
May Report. May, 1890, pp. 4	80,000
June Report. June, 1890, pp. 4	78,000
July Report. July, 1890, pp. 4	78,000
August Report. August, 1890, pp. 4	78,000
September Report. September, 1890, pp. 4	78,000
October Report. October, 1890, pp. 4	78,000
November Report. November, 1890, pp. 4	78,000
December Report. December, 1890, pp. 4	78,000
Report of the Statistician for the year 1889. Author's Edition. (From Report of the Secretary of Agriculture for 1889.) August, 1890, pp. 201-272	1,000

SILK SECTION.

Silk Bulletin, No. 1. How to Raise Silk-Worms. A brief Manual of Instructions, abridged from Bulletin No. 9 of the Division of Entomology. By Philip Walker, Chief of the Silk Section. February, 1890, pp. 16. With illustrations	5,000
Report of the Chief of the Silk Section for the year 1889. Author's Edition. (From the Report of the Secretary of Agriculture for the year 1889.) August, 1889, pp. 453-476	300

DIVISION OF GARDENS AND GROUNDS.

Reports of the Superintendent of Gardens and Grounds for the year 1889. Author's Edition. (From the Report of the Secretary of Agriculture for 1889.) August, 1890, pp. 111-134	500

DIVISION OF VEGETABLE PATHOLOGY.

Journal of Mycology. (Devoted to the study of Fungi, especially in their relation to plant diseases.)	
Vol. 5, No. 3. With plates. November, 1889, pp. 113-180	1,500
Vol. 5, No. 4. With plates. November, 1889, pp. 181-249, with index	1,500
Vol. 6, No. 1. With plates. May, 1890, pp. 44	2,000
Vol. 6, No. 2. With plate and cuts. September, 1890, pp. 45-88	4,000
Vol. 6, No. 3. With plates and cuts. January, 1891, pp. 89-136	2,500
Botanical Bulletin, No. 11. (Section of Vegetable Pathology.) Report on the Experiments made in 1889 in the Treatment of the Fungous Diseases of Plants. By B. T. Galloway. With plates and index. May, 1890, pp. 119	5,000
An Experiment in Preventing the Injuries of Potato Rot. By Clarence M. Weed. (Reprinted from Journal of Mycology, Vol. 5, No. 3.) November, 1889, pp. 158-160	1,000
Peach Rot and Peach Blight. By Erwin F. Smith. (Reprinted from Journal of Mycology, Vol. 5, No. 3.) November, 1889, pp. 123-134	1,000
Treatment of Plant Diseases. (A series of articles reprinted from Journal of Mycology, Vol. 6, No. 1.) May, 1890, pp. 23	5,000
A New Hollyhock Disease. By Miss E. A. Southworth. (Reprinted from Journal of Mycology, Vol. 6, No. 2.) With plate. November, 1890, pp. 45-50	3,000
Report of the Chief of the Section of Vegetable Pathology for 1889. Author's Edition. (From the Report of the Secretary of Agriculture for 1889.) With plates. August, 1890, pp. 397-432	500

REPORT OF THE SUPERINTENDENT OF THE DOCUMENT AND FOLDING ROOM.

SIR: I have the honor to submit herewith my report of the work of the Document and Folding Room during the past year.

Upon this Division devolves the important work of preparing and keeping in order the mailing lists of the Department and of distributing the reports and bulletins emanating from its several Divisions. In addition to this work there must be written a large number of franks and envelopes for the dispatch of circulars and other documents for the press prepared in the Division of Records and Editing, besides the mailing of envelopes and paper to correspondents, return envelopes, etc., aggregating a great many thousands. In last year's report I pointed out in some detail the large increase of work which had devolved upon this Division and which I was compelled to perform with little or no increase in the clerical force. I gratefully acknowledge an increase in the force during the present year by the addition of two folding clerks and one laborer; at the same time I may be permitted to point out that the increase of the work this year by comparison with the last has been quite out of proportion to the increased force assigned to me. It can be readily understood that as the work of the Department develops and new divisions are created additional work is immediately and unavoidably imposed upon this Division. This is so obvious that I shall not attempt to elucidate this matter in detail, but will merely call your attention to the fact that whereas the total publications of the Department for the previous twelve months aggregated 566,000 copies, the total number of copies of the publications for the twelve months just expired aggregated 1,133,000, a trifle more than twice as many copies, the care and distribution of which devolved upon this Division.

It will be unnecessary for me in this report to include a detailed statement of these publications, as an extended list of the same will, I have reason to believe, be included in the report of the Division of Records and Editing. It has only been, then, by unremitting efforts, in which I wish to say I have been cordially aided by my assistants, that I have been able to dispose of the enormous amount of work involved by this great increase both in the number of publications and the number of copies.

In this connection I desire to suggest that the method of keeping the lists calls for some modification looking to improvement in two respects, first, promptness, and secondly, economy in distribution. Some of the Divisions at present write their own franks. As these are occasionally delayed on account of press of other work, corresponding delay in the distribution is inevitable. The force of this Division should in my opinion be so enlarged as to permit of the

keeping of all lists and the writing of all franks under my own supervision. This would enable us furthermore to adopt a system by which any possibility of duplication in the distribution of bulletins or reports would be certainly avoided.

I beg leave to call your attention here to the gratifying evidence, of which the work of this Division affords the most ample testimony, of a rapidly increasing demand for the publications of this Department. It is but a few years ago that little if any interest seemed to be manifested by a majority of the farmers of the country in the publications of the Department even on subjects of vital interest to themselves. All this has now changed, and the mere appearance of a notice of a forthcoming bulletin brings us hundreds and thousands of applications, which continue to be received after the bulletin or report has appeared, until to-day I am constantly obliged to call attention to the rapidly diminishing supply of the several bulletins on hand.

This leads me to suggest the propriety of enlarging the editions if possible, while at the same time it might doubtless be possible to be a little more conservative in our methods of distribution. In many cases, as I have said, thousands of applications are received under the present system even before the bulletin itself has been received from the Public Printer, and as the appearance of the bulletin in print is apt to stimulate the demand, we find ourselves constantly threatened with an exhaustion of the supply on hand. I regret to say that this is the case with the first report of the Secretary of Agriculture, of which only 25,000 copies were assigned to this Department, and of which, in my opinion, judging by the repeated calls, 50,000 copies would not have been an excessive number for our use.

Inasmuch as the work of this Division represents one of the channels through which all the work done in the various Divisions of the Department must pass before reaching the public, and inasmuch, furthermore, as all the work done by us brings the Department in direct contact with that portion of the public for whose benefit it is especially designed, I think the importance of its efficient equipment with a staff of capable clerks, adequately remunerated, the thorough systematizing of its work, and sufficient and suitable accommodation for its prompt and efficient performance can not be overestimated.

Respectfully,

A. T. LONGLEY,
Superintendent of Document and Folding Room.

Hon. J. M. RUSK,
Secretary.

REPORT OF THE SPECIAL AGENT IN CHARGE OF FIBER INVESTIGATIONS.

SIR: I have the honor to present herewith a report upon the investigations of the Department, during the past year, into fiber cultivation in the United States. As the culture of flax and hemp are important recognized industries in which the greatest interest exists at the present time, while the production of ramie, sisal hemp, etc., can hardly claim recognition as established industries, I have devoted the principal part of the report to the consideration of the first-named fibers, confining myself chiefly to matters of culture, or those which directly interest the American farmer.

Upon my return from Europe in November, 1889, where, in pursuance with your instructions a study was made of the flax, hemp, and ramie interests, a line of investigation into American fiber industries was at once entered upon. This has been persistently pushed and the progress of the year, as far as practical results are concerned, has been especially marked in regard to the flax and hemp industries and, in a partial degree, as to those of ramie and sisal hemp. Early in the season the outlook was very promising for success with two or three new forms of fiber material that might be used as jute substitutes in cotton bagging, such as okra and the bast of the ordinary cotton stalk, but no practical results have been secured so far as the Department has been able to learn, and in two or three instances the experiment has been marked with positive failure. I should state that the manufacture of bagging from the fiber derived from pine straw or pine needles is not included in this category, as the present year's operations, with this material, have been quite large.

FLAX.

In considering the fiber interests of our country flax should undoubtedly be given the first place. At the outset of these investigations it was ascertained that flax was grown by our farmers almost wholly for seed, the straw, of inferior quality, when used at all, going to the tow mills or the paper mills, and selling for from $1 to $8 a ton, the average in the different sections being not more than $2.50 to $4, while by far the larger quantity, that which is wasted or burned, represented no money value whatever. While in the older States the area under cultivation was found to be small and steadily decreasing, in the newer States, or States where agriculture

is being pushed steadily westward from year to year, the area under cultivation seemed to be fairly holding its own, and can be stated in round numbers at about one million acres.

As to the method of culture it was learned that in the newer States it is the general practice to grow on "first breaking," or land plowed from the prairie sod, manures being rarely used. On cultivated land it is the custom to grow after corn, grain, or clover, and it is almost the rule to follow with a grain crop of some sort, wheat and oats being most commonly cultivated. Corn is also grown, and sometimes grasses and clover or potatoes. In such cases the ground is prepared as for a wheat crop, barnyard manures being applied; in some rare instances bone or other fertilizer is spread after seeding, and the soil is brought to a fine state of tilth by harrowing. It seems to be generally understood that a fine mellow soil is necessary for the success of the crop, even when grown only for seed, and one or more, sometimes three, plowings are given and the earth pulverized as thoroughly as possible. The seed is obtained at the oil mills, at the local stores, or is imported, some Russian seed being sown in the new States. It is either drilled or sown broadcast, the latter being the almost universal custom. Little or no cultivation is given the crop while growing, and when the seed is ripe the straw is cut with the reaper, the knives set high, and the "self-raker" employed. The straw is run through an ordinary thrashing machine, which leaves it a broken and tangled mass, the coarse fiber it contains being rendered valueless for almost any purpose save upholstery tow. When it is not used for fiber, and not burned or otherwise wasted, it is sometimes employed for thatching, as bedding for stock, or packing for ice, and sometimes as a fertilizer. By many it is fed to sheep and cattle, though its use for this purpose, despite the wide advocacy of the practice by some agricultural writers, can not be condemned too strongly on account of the danger to the animal from eating the fiber in quantity.

At present the area for seed production seems to be increasing, and with the agitation of the present year looking toward the reëstablishment of the flax industry has come the inquiry, oft repeated, whether it will be possible to grow for seed and save the fiber also. To what extent our farmers may grow both for seed and fiber in the same plant is a problem in the solution of which Western agricultural experiment stations can do important work. Or, stated differently, careful experiment can only determine the precise value of a fiber produced without sacrificing the quality of the seed. Many old writers affirm that good seed and salable fiber can not be produced from the same plant, and the statement has been reiterated time and again during the past season. There are two sides to this question, though in the limits of the present report it will be impossible to properly discuss them. Undoubtedly when the flax fiber industry is fairly established in the United States there will be three distinct forms of flax culture. First, the culture for seed only, by present careless methods; secondly, a more careful culture with a view to getting a full crop of seed, while producing a tolerable fiber that will be marketable for certain kinds of manufacture, and lastly, a careful, skillful culture for the production of fine fiber, the seed product being a secondary consideration. We have nothing to do with the first form of culture, so but two forms are to be considered.

The finest flax produced in Europe is grown in Belgium, where the seed not only is saved but is used in some cases to produce the

next year's crop of flax.* In a letter recently received from Mr. John Orr Wallace, a Belfast authority, occurs this statement:

About the fiber being coarse if the seed is saved, this will not be the case if the flax straw is pulled before being too ripe and hard. In France and Belgium our spinners get the finest fiber, and the growers there save the seed.

Here is an extract from a recent number of the Irish Textile Journal, furnishing added proof that fiber and seed can be secured in the same plant. The italics are mine:

The crop must be grown with a view towards getting from the land the highest yield of straw that will produce the *finest quality* of fiber. *The seed, which ought to be a large factor in profit, should be saved*, etc.

In an article in the same journal, relating to experiments in flax culture in the south of Ireland, this statement occurs:

The measured acre of green flax, one week pulled, weighed 5 tons 9 cwt., and yielded 22 bushels of prime seed.

From a careful sifting of evidence it would seem that it is easier to produce salable fiber and salable seed for the oil mill than to grow fine fiber, and at the same time secure seed that will produce equally fine fiber the second year. As there is a certain degree of seed deterioration, necessitating renewal by importation each season, the oil mill becomes an important factor in the enterprise, whatever form of fiber is grown.

Mr. Henry Stewart has stated in the Country Gentleman that "it is futile to expect that fiber and seed can be produced from the same crop." Mr. Eugene Bosse, formerly a Belgian flax grower, but now a citizen of the United States, produced in 1889 a crop of flax pronounced by one of our manufacturers fit for fine linen. His fiber was sold at a good price in Boston, and the same crop yielded at the rate of 10 bushels of seed per acre, for which he received $1 per bushel. Mr. Bosse has produced a large crop of fine flax the present year, in Minnesota, though detailed statements regarding it have not yet been received. According to Mr. Stewart, not only seed and fiber, but *fine flax* can not be grown in America.† Can it be possible that this writer does not know that just over the border, dividing Michigan from Canada, large areas of flax are annually grown, and that almost a score of flourishing mills have been in operation for years? Does he not know that the Canadians are seriously considering the growing of flax for export into Great Britain? What can be done in this section of Canada can be done in Michigan, Minnesota, and other States. Mr. Stewart is correct in his statement, however, that if the plant is left long on the ground the fiber loses its strength and firmness and becomes harsh, brittle, and

* The usual practice in Belgium, as I learned from Government experts while abroad last season, is to import the seed annually, though I found that in some localities a different custom prevailed, as in the Brabant. Imported seed is planted the first year, Dutch or Russian, and the seed product of this crop planted the second year, giving, it is claimed, a better quality of flax than the first year; but for the next year's sowing new seed is again secured.

† My first effort was made in Michigan thirty years ago, after returning from a lengthened visit from Europe, during which I spent a few weeks in the north of Ireland, in the center of the flax-growing district, and later in Pennsylvania. In Ireland I witnessed the latter stages of the culture of this crop, and the preparation of this fiber for sale to the linen factories, several of which I visited. On my return I prepared a piece of land, and had it sown with flax by a man who came from this same district, and who seemed to be as sanguine as I was that we could grow flax in America. But every effort to grow fine fiber failed. A coarse fiber, fit for making grain bags, can be easily grown.

coarse. The plant should not be left "long" on the ground, but as Mr. Wallace suggests, should be pulled before it has become hard and overripe.

Having shown that it is possible to save the seed when flax is grown for fiber, I do not wish to be understood as saying that culture for seed production and culture for fiber production are one and the same thing. When flax is grown for seed, and without regard to fiber, it is sown thin, at the rate of 2 to 3 pecks of seed per acre, in order that the plants shall branch and produce as large a crop as possible. And a large seed is also desirable. When the production of fine fiber is the object, a thicker sowing is necessary, that is, from 1½ to 2 bushels (or even more) per acre are required. This prevents branching, the plants are shaded, and a crop of clean, slender, straight straw is the result. Referring to the original question: Can our farmers cultivate for seed, and also secure a fiber that can be made a marketable product?

In the course of my investigations during the past year, valuable affirmative testimony has been secured from which the following deductions are made. It will be possible to grow flax for seed, *i. e.*, for sale to the linseed oil manufacturer, and also to secure a fiber which will be applicable to many of the coarser uses for which flax is employed, though with some modification of the present (common) method of flax culture in this country. There must be a little better preparation of the seed-bed, making it smoother, so that the farmer will be enabled to run the reaper knives as near the roots as possible and get the full length of straw, and it may be better to sow a little more seed to the acre. He must discard the ruinous practice of tearing the straw into fragments in taking off the seed. Let him keep the straw straight, water-ret it if he will take the trouble, or carefully dew-ret it if he thinks the water-retting will not pay. Regarding the matter of scutching or cleaning the straw, when the better quality of straw is produced, there will be scutch mills if they are needed. In this connection it may be stated that the Department has in its collection some beautiful samples of well-cleaned Western flax, from straw grown for seed but kept straight, that were hackled direct from the breaker, without scutching.*

* A few extracts from the letter of Mr. John Ross, of Boston, which accompanied these samples, will be interesting in this connection. The long experience of Mr. Ross in handling flax fiber, as well as knowledge of the requirements of the industry from the manufacturer's standpoint, enables him to speak authoritatively. He makes statements as follows:

"To obtain the best results as to quantity and quality from the Western straw, as at present sown and cultivated for the seed, I believe that the straw should be cut, or better, pulled and kept straight, and the seed removed by rippling or some similar process which will not tangle the straw. The straw must then be steeped in water in streams, or in pits or ditches, and thoroughly water-retted, the process being carried as far as is possible without positively endangering the strength of the fiber. Then the retted straw must be thoroughly dried, and, if possible, exposed to some artificial heat immediately before being broken. In Holland the straw is dried by exposing to the heat produced by the combustion of the shives and dust from the brakes, and this drying process is attended by a boy. The dry straw should then be passed through a brake provided with several sets of fluted rollers, so that the straw, rendered brittle by the drying process, will be thoroughly broken up, and the greater part of it will fall, and that which remains on the fiber will be loose and will be easily detached by the subsequent processes of hackling, carding, and spinning, thus yielding a clean yarn.

"It will be noticed that this method of treatment omits the process of scutching. This is always the most expensive process in the preparation of the flax fibre, and when applied to so short and weak a fiber as is produced in the West under the

I am informed that these samples were produced from water-retted flax grown near Cedar Falls, Iowa, for seed purposes. They well illustrate the possibilities of this fiber when properly handled and grown as at present without additional expense or trouble to the farmer, except the keeping of the straw straight and the rippling of the seed.

Mr. A. R. Turner, jr., president of the Flax and Hemp Spinners and Growers' Association, in an important and lengthy communication to the Department, last February, made the following statements bearing directly upon this question:

> At present we have a home demand for good flax fiber for yarns, thread, etc., but many farmers who have shown samples have offered inferior flax, raised from poor seed, and the fiber has not been properly cleaned. While the making of threads requires a strong flax, many grades of flax not fitted for threads are suited for weaving, and it is a thoroughly practical matter to make coarse linens from ordinary grades of Western flax when sufficient protection is given the manufacturer in the producing of goods. * * * Some plan should be devised to save all the fiber that is now being wasted, and to me it seems a safe statement to make that it is possible to preserve all the fiber from flax even though it may be sown primarily for seed.

Here is positive testimony from the manufacturer's standpoint, though Mr. Turner does not stop here, but urges the necessity for experiments in "the raising of long and strong flax from the best seed, the aim being to produce the best possible quality of fiber."

This brings us to the subject of fine flax culture, or that form of cultivation where good management and a certain amount of skill are essential to success and where seed is a secondary consideration.

In view of all that has been published during the past year regarding fine flax culture it would seem unnecessary to give any space in this report to the question, "Can we produce fine flax in the United States." There has been such opposition to the revival of this industry, however, chiefly from the American representatives of foreign interests, and so much has been published with the direct object to discourage all attempts toward flax production,* that a few

---

present system of cultivation, it would cause a large product of scutching tow, and would raise the cost of the fiber beyond its market value.

"I send, in the accompanying box, samples of the hackled line and tow produced from Western straw, which has been kept straight and retted in water and passed through a brake without scutching. The samples of coarse line and tow represent a product of 50 per cent line, and about 40 per cent tow, and 10 per cent waste, and are suitable for spinning into medium and coarse twine, and for the warp and weft yarns in coarse crashes, etc. The samples of the fine line and tow show what can be produced from this flax when thoroughly hackled, and from this line can be spun a 50-lea weaving yarn suitable for many of the finer and even some of the finest of the linens on which the Flax and Hemp Spinners and Growers' Association asks an additional duty that they may be made at home instead of imported from abroad. The fine tow is suited for fine weft yarns for weaving purposes."

*I regret to state that not only have prominent commercial journals used their influence in this direction, but not a few of our leading agricultural papers have endeavored to teach farmers this false doctrine, editorially, even with the facts before them, or readily available, that would refute their misstatements. An extract from an editorial published in a leading newspaper of St. Paul, Minnesota, during the summer, comments upon this matter most pointedly: "Either from ignorance or design there has been a general and persistent attempt to discourage the cultivation of flax in this country with a view to utilizing the fiber. Our farmers were taught that a flax crop might be made to pay well if raised for seed alone; but they were given a whole host of reasons why the industry could not stand on the broader ground of a profit from both seed and fiber. This has been so generally the impression that even the ablest of the trade journals have fallen into line, and the public has assumed as a fixed fact that the manufacture of twine or textiles from flax grown in the United States is an imaginary industry."

statements showing the results of the Department's investigations upon this subject will serve a good purpose at this time.

It has been asserted over and over again that neither the soil nor climate of the United States was adapted to fine flax culture.

A perusal of the reports of the Department of Agriculture for a period of forty years, and in connection with the Census volumes, gives abundant evidence that flax cultivation for fiber has been a recognized American industry in the past. In the first half of the present century the flax wheel was as common in the household as is the sewing machine in our generation, while there is hardly a country boy of that early period, still living, who does not remember perfectly every operation related to culture, as well as the subsequent ones connected with the preparation of the fiber. The flax of New York and New England of sixty to seventy years ago is described as strong and flexible, though not always as clean as it should have been, and sometimes uneven in quality; and good flax was grown in New Jersey. The history of the flax culture from that time down to within a score of years of the present time is a history of flax fiber production in varying quantities, the most of it being good staple flax.

The decline of the industry is due, first, to the change from household manufacture to that of the central spinning mill, to the increasing use of cotton, to the war period, to the tariff revisions of 1872 when the flax industry had begun to revive, and latterly, as stated by Mr. Turner, to the fact that encouragement has not been given to the raising of flax because the supply of linens is principally imported and we have lost our position as manufacturers in the linen trade.

Were linen factories scattered over our country, and especially through the Northwestern States, a demand would be made for flax by the manufacturer which the American farmer, if he produces good fiber, can supply. The increase of duty on the dressed line flax from 2 to 3 cents per pound should certainly aid the farmer in his effort to fill this demand. It is urged, however, that farmers not only will never pull flax, but that when it comes to the retting (in pools, of course) no American farmer will ever take the trouble to learn the business. These are very broad statements, which hardly merit a reply. It may be said, however, that a common practice abroad is for the farmer to sell the crop standing in the field and frequently before it has completed its growth. As the purchaser attends to the pulling, retting, and scutching, the farmer's responsibility really ends when the weeding has been accomplished. Indications already point to the adoption of this course in America, for in those localities where the industry is beginning to revive the linen factory, scutch mills, and flax farms are component parts of a comt mon interest, and are but wheels in a single machine. Under present conditions and with a reduced foreign supply the American manufacturer will be able to pay a better price for his dressed flax, no matter who dresses it, and so, in connection with this encouragement, insure the paying of better prices to all who handle the product, right down to the farmer, whether he rets his crop himself or sells it standing.

To return to the question whether we have the proper soil and climate for flax culture, and can grow flax, I will say that good flax was grown last year in several States, samples of which were sent to the Department, one of them even coming from Texas, produced by a former Irish flax grower.

A study of meteorological data obtained from the Weather Bureau in Washington reveals some interesting facts. In the discussion upon flax culture a great deal has been said about the hot, dry climate of the United States in comparison with the cool, moist climate of Ireland; but if the truth must be stated the best flax is not grown in Ireland, nor is the best flax spun by the Belfast manufacturer produced by Irish farmers, but by the growers of Belgium.

The best American flax I have seen was grown at Green Bay, Wisconsin, where the average temperature for the three growing months is 54° F., and with abundant rainfall. The average temperature of Belfast, Ireland, for the same period is 52.2° F., and for Brussels, Belgium, 55.9° F. The temperature for St. Paul, Minnesota, near which station superb flax was produced this season, is only a fraction of one degree higher.

Studying the figures for humidity we are enabled to make further interesting comparisons: For Brussels, Belgium, the average for the three growing months is 77.4 and the average annual 83. For Green Bay, Wisconsin, average for three months 72 and for the year 77.9. For Cologne, Germany, the average for April, May, and June is but 67.1 and the annual but 74 (contrast with Green Bay), while for St. Paul, Minnesota, the averages are, respectively, 65.6 and 71. An effort was made to ascertain the humidity for Belfast, but persistent search through the records of the Weather Bureau, as well as all available publications running back forty years, was unsuccessful. On the authority of an expert linen weaver, formerly of Belfast, the average humidity for that station is stated to be 70 to 72.

For better comparison the following table is presented:

From records of the Weather Bureau.

	Temperature.		Humidity.	
	Average* 3 months.	Average annual.	Average 3 months.	Average annual.
Foreign stations—	°	°		
Belfast, Ireland	52.2	48.8	....	....
Brussels, Belgium	55.9	....	77.4	83.4
Prague, Bohemia	54.6	48.1	66.0	74.0
Cologne, Germany	55.7	50.6	67.1	74.0
American stations—				
Albany, New York	57.7	....	64.5	70.5
Green Bay, Wisconsin	54.0	....	72 0	77.9
St. Paul, Minnesota	56.7	....	65.6	71.0
Portland, Oregon	56.9	....	66.7	83.0

*April, May, and June.

By this table it is shown that the temperature of the leading flax-growing sections of this country and Europe is practically the same, the average for the four European stations being 54.3°, and for the four in the United States 56.3°, or a difference of but 2°. The humidity for the foreign stations given is slightly higher than for those of this country, though stations indicating greater humidity in the States named and near which fine flax can undoubtedly be produced, could have been used. The humidity of Washington, as indicated by the data from Spokane Falls, Olympia, etc., will be found almost as great as of any foreign stations reported, and there is no doubt but that good flax can be grown in this new State.

Though the process of bleaching or "grassing" belongs to the manufacturing branch of the industry and does not interest the farmers it may be stated that the process has been accomplished in this country with quite as good success as in Europe. Some fine samples of linen thread from a large New Jersey manufacturing firm may be seen in the collection of the Department, which were bleached out of doors in less time than it takes in Belfast when the same process is followed. As we have in many localities the right temperature, rainfall, and humidity to grow flax, the proper conditions for bleaching it, and as spinning flax was produced on nearly every farm in the country fifty or sixty years ago, and good flax was grown in several localities the present year, it is nonsense to protest that flax culture is not adapted to the United States.

Another point urged by the friends of the foreign producer is that it is doubtful whether flax culture will pay in this country. We are told that the American farmer can never compete with the foreign grower who pays 50 cents a day for his labor. Neither could he, were the conditions equal; but a careful study of the situation on both sides of the Atlantic reveals the fact that the conditions are so unequal that in many things the American farmer has a positive advantage, which, with a few years of experience and aided by the persistence of American inventive genius, will make him master of the situation.

In the first place the foreign flax farmer is obliged to use an enormous amount of fertilizers, because the lands, worked for centuries, will not produce paying crops without. Stable manure is freely applied in the fall. Then in the spring, before sowing time, the soil is again heavily treated, but this time with chemical fertilizers, often at the rate of 500 to 750 pounds per acre. In addition to this many farmers go over the ground with night soil in solution, and a great deal of this material is brought from the towns and kept in large closed reservoirs until time to use it. I have no figures at hand showing what the rent of land amounts to, but it is so far in excess of land rentals in this country that it is no wonder flax culture is being abandoned in many localities because the grower can not get enough out of it to meet his expenses. It is true he gets his labor at exceedingly low wages, but the foreign farm laborer is slow and plodding. Much of the flax is grown by small farmers upon limited areas, and the small farmer does not use labor-saving machinery.

An American farmer would never think of spading over a 10-acre field, when with horse implements he could do the work better in a quarter of the time. And what American farmer, wishing to roll his ground, would strap boards to his feet and level it by tiresome tramping up and down, when with a horse roller the work could be finished in a few hours, and enable him to ride while accomplishing it. Yet these are some of the "foreign methods" of flax culture that are practiced at the present time. I was told by hemp farmers in Brittany that a French laborer who breaks out 65 to 75 pounds of fiber (on a hand brake) has performed a good day's work, yet a Kentucky negro, using a similar hand implement, will make 150 pounds. From my observations last year in the foreign flax countries visited, I have no hesitancy in saying that one average farmer or farm laborer in this country will accomplish as much as two abroad. And with the application of labor-saving machinery to all the operations in flax culture, the difference in the prices of farm labor alone will be more than compensated, and the cheapness of

land and the natural fertility of the soil in this country will give a clear advantage on the side of the American flax grower. The soil will be plowed, harrowed, crushed, and rolled with improved machinery. A mechanical flax-puller has already been invented, and there are several improved machines for taking out the seed without injury to the fiber. We lead the world in the invention and manufacture of agricultural implements, and when the demand is made by flax farmers for improved implements for special purposes in this branch of agriculture they will be produced. And when our farmers have had a few years' experience, and this "American practice" of accomplishing hand labor by means of iron and wood and horseflesh, instead of human sinew and muscle, is adapted to flax culture, we shall be in position to outsell the European grower in his own market.

Cultivation.—As I have stated, the growing flax for fiber and growing for seed and saving the fiber, such as it is, are two distinct kinds of flax culture. For the benefit of those who may wish to try the experiment of growing flax for fiber, the following brief instructions have been prepared. A great deal depends upon the selection of the soil, a moist, deep, strong loam upon upland giving the best results. Barley lands in the Middle States and new prairie lands or old turf in the Western States are frequently chosen. Some former New York flax growers inclined to a heavy clay loam for the production of fiber and seed, though the choice of a wet soil will be fatal to success. In Russia flax culture is carried on upon the vast plains in the interior subject to annual overflow from the rivers. In Belgium, as I was informed, flax succeeds best in a deep and well-cultivated soil that is not too heavy, experience proving that in a dry, calcareous soil the stalk remains short, while in heavy clayey soil it grows very long, although its fiber is not so fine.

A soil full of the seeds of weeds is to be avoided above all things, and the American farmer who is not overnice in regard to clean land had better let flax culture alone. Not only does a weed-ridden soil add greatly to the labor of making the crop, but the fiber itself will be injured. Clean land, then, is one of the first requisites to success. In Europe the ground is plowed either in the fall or spring—plowed or spaded, for a great deal of the flax land is turned with the spade. The work may begin in November, sometimes a little earlier, or it may be put off until February, or the first days of March. I was told that both methods had their advocates and opponents, and that either season may be advantageous or disadvantageous, according to the kind of winter which follows or precedes. In our own country fall plowing is desirable with a second plowing in the spring as early as possible. Then harrow, reduce to fine tilth, and roll the ground well before putting in the seed. Mr. S. Edwards Todd, in a prize essay on flax culture published several years ago, laid great stress on the matter of reducing the soil to fine tilth and rolling well, the object being to have the surface of the ground as smooth and uniform as it can be made, so that the flax may get an even start, grow more uniformly, and the surface of the ground be better to work over when the flax is pulled. All stones should be removed or pressed into the earth, and lumps are to be equally avoided.

Reference has already been made to the thoroughness of the foreign grower in keeping up the fertility of the soil. The American farmer, and especially on the newer lands of the Western States, doubtless will not need to manure as heavily as is done on the other

side of the water, though present practices, followed in many localities of the West, of taking everything from the soil but the roots of the plant and returning little or nothing, will have to be abandoned. Phosphates, plaster, ashes, and salt are considered the best manures. Dr. Ure recommends a mixture of 30 pounds of potash, 28 of common salt, 34 of burnt gypsum, 54 of bone dust, and 56 of magnesia, which he claims will replace the constituents of an average acre of flax. Well rotted barnyard manure should be used in preference to coarse barnyard manures, which are apt to make too rank a growth to produce good fiber. As before stated, Belgian farmers use liquid night soil or other liquid manure collected from the cow-house and stables, fermented in cisterns, and sometimes mixed with oil cake.

The American farmer must not depend upon careful soil preparation and fertilizing alone to put his flax land in proper condition. A systematic rotation of crops is absolutely essential in order to secure the best results. A former New York grower used to begin the preparation of the soil for a crop of flax three years before. The rotation followed was Indian corn, barley, oats, winter and spring wheat, and red clover, the corn being planted on land plowed from clover sod. The cleaning process, to rid the soil from weeds, began with the first crop which followed the clover sod. Rotation in Europe is reduced to such system that oftentimes the entire farm is laid off in plots and the order of planting for the different crops planned for several years in advance. The Belgian farmers are particularly careful in this matter. Regarding the precise order of rotation and even the length of time between two growths of flax on the same land in Belgium, there is the greatest difference of practice in the several districts and even in different towns of the same district, so no one absolute course of cropping can be laid down. In the Courtrai region the occupancy of the land with flax varies from five to ten years, the average being about eight. In eastern Flanders it is five to nine, and in the Brabant five to eight. In some other sections a much longer time elapses between two crops of flax, and several generations back fifteen and even eighteen years were sometimes allowed to intervene. One informant stated to me that flax was most generally sown after leafy plants, such as potatoes or turnips, wheat and especially oat-stubble being highly approved. A common rotation is clover, oats, rye, wheat, and in some cases hemp. Crops of rape, tobacco, beans, and vegetables (these latter crops on farms contiguous to towns), or even onions and salsify, are grown, as in middle Belgium. Clover is considered one of the best crops to precede a crop of flax, as its numerous roots go deep into the soil and from their decomposition not only furnish nutriment to the growing flax roots, but enable them more easily to push down into the soil.

After a thorough preparation of the ground, which must be almost as fine as garden soil and of absolutely even surface, the seed may be sown; and again, at this point, great care should be exercised, for upon a careful selection of the seed much depends. It must be pure, free from the seeds of weeds, and from all odors which would indicate mustiness and bad condition, that would affect its germinating power. The foreign grower in purchasing his seed is subjected to a dozen forms of fraud, and the only safe plan pursued is to buy of reputable dealers exclusively.

In all cases the heaviest, brightest, and plumpest seed should be preferred. Get only the best. Mr. J. R. Proctor, of Kentucky,

writing upon this subject ten or twelve years ago, advocated the white blossom Dutch as the best seed for American flax growers. Mr. Eugene Bosse, a practical flax grower, writing to the Department under recent date, states that his preference, based upon several years' experience, is for (1) "Riga seed, once sown in Belgium"— that is to say, imported seed grown on Belgian soil from seed procured in Riga. Next to this he places (2) seed imported direct from Riga, but states that it must be Riga and not Finland seed. Third in the list he places (3) Dutch (Rotterdam) seed, and lastly (4) American seed, which is "as good as Nos. 2 and 3 when well cultivated, though it will not stand the drought as well." He also states that No. 1 will produce about 8 bushels of seed to the acre,* No. 2 10 bushels, and No. 3 between 8 and 10 bushels. Note that he calculates for the rate of seed production, even when stating the relative value of the different kinds for the production of fine fiber.

As to quantity, 2 bushels per acre is the smallest that should be sown when good results are desired. When sowing for the production of seed alone, 2 pecks to a bushel will suffice. The larger the quantity of seed, therefore, the finer the straw, and likewise the fiber. The amount of seed sown in Belgium varies ordinarily from 2½ to 3 bushels per acre, though in one district (Hainault) it is claimed that the quantity sown is sometimes double this amount. Probably 3 bushels per acre comes nearer the general practice. Some growers hold that more should be used when the sowing is late than when it is early; at any rate, when planted too thickly, as is sometimes the case, it is afterwards thinned, though such a practice adds just so much to the cost of production. Finer fiber is obtained from early sown flax than from later sown.

As to the proper time to sow in this country a former grower in New York State says: "Sow when the soil has settled and is warmed by the influence of the sun and weeds and grass have begun to spring up and the leaves of trees begin to unfold."

Mr. Avan Hemert, writing to the Department from Grand Meadow, Minnesota, says:

> No definite rule can be laid down as to which time in the spring is the best to sow flax, atmospherical conditions governing the growth to a great extent. I consider for myself the first part of May is the best time for seeding it.

Too early sowing may result in injury to the growing plants. The work must be done with great regularity; in fact, in foreign countries many farmers employ for this purpose special workmen who make it their business at this season of the year. A practice followed by some farmers, especially where the soil is at all weedy, is to allow the land to lie, after it is put in condition, until the weeds appear, then, just before sowing, give the surface a light harrowing, when the majority will be killed. The weeding, when necessary, is performed when the plants are less than 5 inches high. Mr. Todd's practice for the removal of the coarser noxious weeds like thistles, dock, etc., is to send a man into the field shod with three or four pairs of woolen stockings, to avoid injury to the young flax by treading it into the soil. This is done when the plants are about 8 inches high. In the operation of weeding some attention should be

* In Mr. Bosse's detailed account of his flax crop of 1889 he states that 1¼ bushels of seed were sown to the acre. He obtained about 620 pounds of fiber and 10 bushels of seed to the acre, the flax selling for 11 cents a pound and the seed at $1 per bushel. He reckons the expense side of the account, including freight on the product, at $42, and his profits at $38.17 per acre.

paid to the condition of the soil, as it must be neither too wet nor too dry. On clean soil one weeding will suffice, but sometimes two or three are necessary. As to the proper time to harvest the crop no general rules can be laid down. Those who heretofore have grown only for seed will be inclined to allow the heads to ripen well, to the injury of the fiber. This matter has been fully discussed on another page, however, and experience doubtless will prove the surest guide. As to the manner of harvesting, the common practice in the West is to use the reaper. If the land surface is made smooth so that the knives can be set low, this may answer for general purposes, though several inches of the best portion of the stem is lost. In fine fiber production there is no question that the crop should be pulled; that is, the plants drawn out of the ground by the hand and the dirt knocked off against the boot, which is the usual manner of procedure. The straw is then laid in handfuls crossing each other so as to be readily made into bundles or "beets."

Subsequent operations.—Securing the seed is the next operation after the crop is harvested, and this is called "rippling." There are special machines to accomplish this, besides improved thrashers, although the work can be done, in a way, in an ordinary thrashing machine by opening the "concave," so that the teeth will just come together; then, with one man to open and pass the bundles, another takes them by the butt ends and spreading them in fan shape, presents the seed end to the machine. The straw is not released, the operator withdrawing it again as soon as the seed has been torn off. With a whip the loose seed is shaken out and the flax rebundled. Some, however, perform the operation without breaking the bundles. The best method of separating the seeds is to pass the heads through plain rollers, free at one end, which avoids injury to the fiber, and there are powerful machines for this purpose to be obtained in Great Britain. Whipping out the seed against a sharp stone set up at an angle of 45 degrees is a New York method. Two or three smart blows, the bundle being held in both hands, will accomplish the result.

Now comes the important operation of retting. In this country the fiber is separated from the stalk by dew-retting almost wholly. The best results are accomplished by the foreign method of water-retting, which necessitates the building of "steep-pools" especially for the purpose. A moist meadow is the proper place for dew-retting, the fiber being spread over the ground in straight rows at the rate of a ton to an acre. If laid about the 1st of October and weather is good, a couple of weeks will suffice for the proper separation of the fiber and woody matter. When the retting is progressing unevenly the rows are opened with a fork or turned with a long pole.

For water-retting, the softest water gives the best results, and where access can not be had to lakes or sluggish or slow-running streams, "steep-pools" will have to be built.* A pool, 30 feet long, 10 feet wide, and 4 feet deep, will suffice for an acre of flax. Spring water should be avoided or, if used, the pool should be filled some weeks before the flax is ready for it, in order to soften the water. It should be kept free from all mineral or vegetable impurities. The sheaves are packed loosely in the pool, sloping so as to rest lightly on their butt ends, if at all, for it is considered best to keep

* There is always objection to retting flax in quantity in the running streams, for sanitary reasons as well as danger of killing the fish.

the sheaves entirely under water without allowing them to come in contact with the bottom. Irish growers cover with long wheat straw or sods, grass side down, the whole kept under water by means of stones or other weights. Fermentation is shown by the turbidity of the water and by bubbles of gas, and as this goes on more weights are required, for the flax swells and rises. If possible, the thick scum which now forms on the surface should be removed by allowing a slight stream of water to flow over the pool. The fiber sinks when decomposition has been carried to the proper point, though this is not always a sure indication that it is just right to take out. In Holland the plan is to take a number of stalks of average fineness, which are broken in two places a few inches apart. If the woody portion or core pulls out easily, leaving the fiber intact, it is ready to come out. The operation usually requires five to ten days. In Courtrai a second retting is sometimes given.

When the retting has been accomplished the bundles should be taken out by hand—for the use of pitchforks may injure the fiber—and set up on end that the water may drain off gradually; twenty-four hours is a sufficient time. Then the bundles are opened and spread evenly over a newly mown grass field, to cleanse the fiber and improve its color, being turned occasionally by poles that it may color evenly. Three or four days will suffice for the grassing, and then, if thoroughly dry, the flax is ready to lift, tie in sheaves, and be put under cover, ready for scutching. As the farm operations end at this point it will not be necessary, in the limits of the present report, to go into details regarding the cleaning of the fiber.

Enough has been stated to prove that fine flax *can* be grown in the United States, and it only remains for our farmers to make the trial. I can but reiterate the statement made in a former report that there will be obstacles to overcome at the outset, of course. But the American farmer is progressive; he has brains and ambition, and inventive genius will aid him in surmounting many difficulties if he will work intelligently and stick to it—not one year or three, but year after year—growing each season a little flax, growing it well, and striving, with the acquirement of skill and experience, each year to produce the best results, and in the end he will be enabled to successfully compete with the foreigner and drive his product out of the market.

HEMP.

One of the results of the excitement caused by the high prices of binding twine, a year or so ago, has been to bring into greater prominence the cultivation of the common, or American hemp. Until recently the great bulk of this fiber produced at home was grown in Kentucky. Of late years, however, its cultivation has been extending in States north of the Ohio River, and during the past two seasons it has been grown to a considerable extent in New York, Illinois, and Missouri, while Minnesota and a few other States have contributed small areas.

As the aim has been, chiefly, to produce a grade of fiber that could be sold at a low price, for such coarse uses as binding twine and the cheaper wrapping twines, much of the labor attending the culture has been accomplished by machinery, and with the agricultural implements found on almost every farm in the West. The plan in vogue in Illinois, as reported to the Department by Mr. John

Heaney, of Buckley, is to sow the seed as early as possible after the ground is in condition, March 25 being named for the season of 1889. The land is plowed in the fall if possible, and in spring the large disk harrow is used, followed by the smoothing harrow. The seed is put in with a broadcast seeder and afterwards carefully harrowed. When the crop is ready to harvest it is cut with mowers, and spread evenly that the retting may be accomplished without the labor of turning over. If rainy, however, the Bullard hay-tedder is used to change the position of the straw or stalks, and to expose to the air the inside of any bunches that might be left to the action of the rains.

When retted the stalks are raked up with the horserake and loaded upon the wagons to transport to the breaker. Mr. Heaney says that 8 to 10 tons of straw per day can be taken care of. The fiber is not kept in a straight form, as the twine-makers break it up on the cards, and this form of fiber suits them better. Here are some of Mr. Heaney's facts, furnished the Department early in 1890:

> I can furnish the clean fiber at 4 cents per pound at a profit. I have 800 acres of hemp this year betwixt this place and Peotone, Illinois. I have shipped already 60 tons of fiber to the spinning mill this fall and winter, from Buckley. I have one field of 140 acres from which I am expecting to get 1,500 pounds of fiber to the acre. It usually costs $15 per acre for rent and labor—on the product of an acre delivered on board cars. If the people would but take 3,000,000 acres of land out of the corn, and oats, and wheat culture, and grow hemp, we could then consume all our grain at home and save the millions we annually pay out for fibers. It would relieve the present agricultural depression wonderfully. All this fine country can raise good hemp wherever it can raise a good crop of anything else.

Notwithstanding that the aim is to produce a cheap fiber it must be admitted that this is a careless kind of cultivation which may not always give satisfactory results. In a communication from another source the danger of overretting is referred to, and the statement made that in practice a difference of 50 per cent is found to exist between well saved and badly saved hemp on the same ground.

In New York State, where for two years past hemp has been grown in the neighborhood of Troy and Schaghticoke for the Cable Flax Mills, a considerable amount of good fiber was produced. I am informed by Mr. Hartshorn, of the Cable Mills, that the crop of the present season did not turn out well, although in 1889 the farmers engaged in the enterprise made money from hemp culture.

Referring to the figures of production, the best record of income from the sale of a crop, net proceeds per acre, cost of seed deducted, was $76.48. The second best was $58.38, and the best five crops averaged $49.71 per acre, exclusive of the cost of seed. The total average of twenty crops—that is, the crops on twenty farms, including one complete failure and another crop which was almost a total failure from the drowning out of the plants when they were 18 inches high—was $18.22 per acre. Sandy or loamy soils are considered most favorable, the hemp succeeding both on the "uplands" and in the "bottoms." The soil is plowed very deeply and made very mellow by the use of the harrow. Barn-yard manures or standard fertilizers are used, as the soil must be put in good fertility to produce a successful crop. The seed is sown from April 20 to May 10, and the crop is usually harvested between the 1st and 21st of September. When the stalks do not exceed 8 feet in height, the cutting is done with an ordinary sweep rake harvesting machine by cutting two thirds the ordinary width of the swath, while a

larger growth must be cut with a sickle, corn hook, or short scythe. It is claimed that a light frost will not injure the crop and that there need be no haste in cutting it, the plant continuing to grow until the stalks have turned a pale yellow. However this may be the opinion in New York State, where the fiber is employed in the coarser manufactures, a different idea prevails abroad; namely, that after the proper time for cutting has arrived the fiber deteriorates, and for fine manufactures there would be considerable loss in value.

Mr. W. B. Hawkins, of Lexington, Kentucky, details the general practice of growers in his State, at the present time, as follows:

The usual procedure in the cultivation and handling of hemp is about this: Our best land produces the best hemp. Virgin soil sown to hemp can be followed by hemp for fifteen to twenty years successively; sown then to small grain and clover; can be sown to hemp every third year (no fertilizer required) almost indefinitely. Given bluegrass sod: Plow not over 4 inches deep in the fall or early spring; sow about the time to plant corn; sow broadcast 33 pounds of seed per acre, having first prepared the seed-bed thoroughly, and cover by dragging with the harrow, as for any of the small grains, wheat, oats, etc. No cultivation can be done, of course, as it is broadcast.

About one hundred days are required for the crop to mature ready for the knife, or when the first ripe seed can be found in the heads. The hemp is then cut and spread thinly, covering the ground it grows upon; it must be kept from tangling. Let it lie for one or two weeks to cure; rain will not injure it in this time. Now rake into bundles and tie (be careful to keep straight), about 10 inches in diameter, and stack dry, about 2 acres in the stack. About December 1 we spread on the ground, as before, and when retted sufficiently set upon end in shocks about the ordinary size of corn shocks, and the hands can carry their brakes from one shock to another in the field to brake it out. Much depends upon the retting, and must be determined by testing when it is ready to take up. The approximate cost of an acre of hemp in Kentucky, counting man and team worth $3.50 per day, is as follows:

Plowing	$2.00
Harrowing	1.00
Seed, at $3	2.50
Cutting	3.00
Taking up and shaking	3.00
Spreading	2.00
When retted, shocking	1.00
Braking, $1 per 100 pounds (the usual crop being 1,000 pounds)	10.00
Total	24.50

The fact that American hemp can be grown in Northern States at a cost of 4 cents per pound, or less, should open the eyes of our Western farmers who have been compelled to pay such enormous prices for binding twine made from imported fiber. In the manufacture of this twine manila hemp, from the Philippine Islands, and Mexican sisal hemp are largely used. About the time that these investigations were begun the market price for sisal hemp was 8½ cents per pound, while manila was nearly 12 cents. And the prices at the beginning of the year previous were several cents higher than these figures. Yet American hemp, or even flax, could have been employed at this time for the raw material of binding twine, at a cost of one third to one half the price of sisal grass, or one quarter to one third that of manila, with the additional advantage that the Western farmers could have produced the hemp. It is not my purpose to discuss here the causes of the high prices of these fibers last year. Enough to say that there was a combination or "understanding" among cordage manufacturers who were thus enabled to control the supply of raw material, and make it impossible for outside parties to buy fiber. It furnishes a beautiful illustration of the

folly of relying upon a distant market for a product for which there is a constant and regular demand, and emphasizes the point that monopoly always cuts the throat of competition. Were the grain growers of the West to demand American hemp twine and use no other, raising the raw product on Western farms, it would be next thing to impossible for any combination to bring about such high prices as were charged for binder twine a year or more ago.

There is no reason why hemp culture should not be extended over a dozen States and the product used in manufactures which now employ thousands of tons of imported fibers. In the manufacture of binder twine alone there is an outlet for upwards of 50,000 tons of hemp annually. Manila is no better than hemp, and sisal quite inferior. American hemp twine is said to run 100 feet more to the pound than sisal, 5 pounds of this twine, at the same price per pound as sisal, going as far as 6 of sisal, an advantage of about 17 per cent in favor of American hemp. (See letter of D. M. Osborne & Co., on another page.)

When the market for binder twine was first created American hemp filled the demand, the more carefully prepared article, straight or dressed hemp, being employed. About ten years ago the demand increased to a point beyond the supply of native hemp, and to meet the exigency of the case other fibers were employed. Manila and sisal came into use, and as the consumption of binder twine grew to its present enormous proportions, these fibers held their position, and hemp was relegated to the background.

The grain growers should be the hemp producers, and in point of fact only take from their own pockets in buying twine what they would get for their raw hemp, with the simple cost of manufacture and dealers' profits added. As a relief from the unwarranted high prices of binder twine during the last two seasons a demand was made to Congress to remove the duty on all so-called hemp substitutes. This meant a reduction of 1 cent per pound average for the different fibers. In my opinion a surer and a more permanent relief for the consumers of binding twine would be the distributing among them of the $4,000,000 or $5,000,000 which the production of this fiber would mean, with an additional saving in the difference in price between the twines made from the native and the imported fibers. It is estimated that not over 5,000 tons of American hemp twine were used the present year. Last spring this twine was quoted in carload lots at 12½ cents against 16 for manila. If only one half of the binder twine output of last year had been made of hemp, at these prices, there would have been a clear saving of $1,750,000 to the consumers in a single year from difference in prices alone. From all that I have been able to learn there is no question but that the machine binders will work with hemp twine quite as readily as with the stiffer twines from sisal and manilla, when a well-made twine is used.

A great deal has been said on this subject, the principal objections coming from those who are especially interested in manila and sisal, but the fact is, and it can be proved by abundant evidence, that the "prejudice" against hemp twine has no substantial foundation. I have taken pains to investigate this matter thoroughly, and have had no trouble in securing testimonials in favor of the use of American hemp twine both from farmers and manufacturers, one of which I take pleasure in publishing entire. It is as follows:

[D. M. Osborne & Co., manufacturers of harvesting machinery.]

AUBURN, N. Y., *March* 29, 1890.

DEAR SIR: We have your esteemed favor of the 26th instant, making inquiry as to our judgment of the value of American hemp twine, commonly known and called as "Kentucky hemp binding twine" for harvesting machinery.

We have sold several thousand tons of this twine, and without exception it has given the best of satisfaction to the farmers using it on their self-binding harvesters. The standards for binding twine are, pure sisal, 500 feet long; half manilla and half sisal, 550 feet long, and pure manilla 600 feet. American hemp when spun 525 feet long is the equal of sisal, half each sisal and manilla, or pure manilla, of the lengths given above.

There is no fiber in the world better suited to this use than American hemp. It is our judgment, based upon nearly ten years' experience with large quantities of binder twine each year, that the entire supply of this twine should be made from American hemp. It has been demonstrated that this hemp can be grown in the States of Kentucky, Missouri, Kansas, Southern Iowa, Southern Illinois, Indiana, Ohio, and New York, and probably several other States that are adapted to raising winter wheat. There are 50,000 tons of this binding twine used annually, every pound of which could and should be made from this home product.

Your Department can do no greater service to the farming community than by widely disseminating the information as to the extent of the use of this twine for binding purposes, and the fact that American hemp is not a difficult crop to raise, and that the usual average yield upon good soil is from 1,000 to 1,500 pounds of hemp per acre.

Very truly yours,

D. M. OSBORNE & CO.
By G. W. ALLEN, *Treasurer.*

CHAS. RICHARDS DODGE, Esq.,
Special Agent Fiber Investigations.

If the Western farmer objects to paying high prices for binding twine he has at least a partial remedy in his own hands. He will find it to his advantage to grow American hemp, and use the twine made from American hemp. If necessary, I would even advocate farmers' interesting capital in the erection of twine mills at home. They would then have a direct interest in the question of the supply of raw material, upon which price must more or less depend.

SISAL CULTIVATION IN FLORIDA.

I have referred to the use of sisal hemp in the manufacture of binding twine. Only a portion of the sisal imported is used, however, in this form of manufacture, but it is largely utilized for making cordage. Recently there has been considerable interest in the subject of producing our own sisal, and of late so many inquiries have been made regarding the industry that a special bulletin is now under preparation, giving the results of my investigations.

The question of growing sisal hemp (*Agave rigida* var. *sisalana*) in the United States was first agitated about 1834, when Dr. Henry Perrine, United States consul at Campeachy, introduced into Southern Florida a few plants from Yucatan. In the fifty or sixty years which have intervened between that time and the present these plants have been so multiplied, from different causes, that the Agave is now found abundantly in many localities. In recent years the attention of the Bahaman Government has been called to the value of the sisal industry, and considerable areas have been covered largely from plants secured in Florida. The success of the enterprise is assured, and samples of fiber sent to London were pro-

nounced better than the Mexican, and quoted at a much higher price per ton. Judging from the samples of Florida sisal received by the Department during the past year, I am satisfied that as far as the mere question of ability to grow the plant is concerned, sisal may be cultivated as successfully in Florida as in the Bahamas, and as good a fiber can be produced. As to the cost of production, not as much can be said at present, for the attempt has not yet been made to produce fiber in marketable quantity. The removal of the duty of $15 per ton will now make it harder to compete with the foreign fiber, though the nearness to market, and the use of improved machines in preparing the fiber may help the matter a little. When the new industry has made further progress, it might be well to consider the expediency of affording to it encouragement in the form of a bounty, for a term of two or three years. I should state that the Bahaman Government has placed a bounty on the production in the British West Indies.

Several companies and individuals are actively interested in the new enterprise and plantations are being established. One near Jupiter, of about 60 acres, has been established for two or three years, and is doing well, leaves large enough for fiber having already been produced. There are several machines of American invention for cleaning the fiber which give promise of success, and altogether the outlook seems hopeful. In the limits of the present report it will be impossible to go into detail regarding the results of my investigations, which are not fully completed, and the information collected must await later publication.

RAMIE.

Regarding the agricultural phases of the ramie industry there is little in the way of progress to report at the present time, although there seems to be a widespread interest in the subject. Practically the culture is at a standstill, both here and in Europe, the knotty problem of economical decortication of the stalks when grown not having received satisfactory solution. In my special report on ramie, published in the spring, the machine question, as far as European investigations are concerned, was fully discussed. Regarding American machines or processes there is nothing to be said at the present time, as the Department has been unable to make any tests showing capacity for a day's work. Without considering the question of the amount of fiber that may be produced in a given time, there are several American machines which effect the decortication successfully and leave the fiber straight. Whether they will come up to the record of foreign machines, or do better or not so well, when the trials are finally made, remains for the future to determine. What was stated in the ramie bulletin published in the early part of the year must be reiterated at the present time:

> To those who know nothing of the story it may be briefly stated that the invention of machinery and processes for the extraction and cleaning (degumming) of ramie fiber in the last thirty years in the various countries where experiments are going on might foot up a hundred or more could the entire catalogue be enumerated. In spite of the vast inventive effort, ramie, up to the present time, has not been grown in any country (excepting China and Japan) save in a limited way, because no machine or process for decortication thus far has been presented that has filled all the requirements demanded of a thoroughly practical decorticator.

It should be stated that while little of importance has been done in the past year which would give evidence of progress in culture, there are indications that some considerable areas will be planted the coming season. The interest is greatest in the States of Louisiana, Texas, and California. Should a practical decorticator be presented during the coming season, or should any of those now under experiment fulfill the requirements of the economically successful machine, ramie culture is in favorable condition, I think, for early establishment of the industry.

In the field of manufacture considerable progress has been made, especially in New England, and while the industry at this time has hardly more than passed the stage of experiment, from what I have seen in the course of my official investigations, and from examination of samples of yarn and fabrics produced, the first named by the ton, I have good reason to believe that American ramie manufactures will soon be on the market. The Department has been able to secure the beautiful exhibit of Mr. Charles Toppan, illustrating the progress of this manufacture in New England from Chinese fiber cleaned by his process, and which was displayed at the recent Mechanics Fair held in Boston. In this collection are shown fine and coarse yarns, dress goods, piece goods, blankets, carpets, upholstery fringes, duck or sail cloth, hammocks, fish nets, etc., in addition to a series of samples exhibiting every stage of manufacture. Some beautiful samples of fine spun yarns, produced on silk machinery, have also been received from Mr. S. S. Boyce, of New York, also from Chinese fiber, which illustrate the possibilities of manufacture in this direction. With a practical machine for cleaning the fiber from the stalks, the success of the industry will be assured.

OTHER FIBERS.

I regret that the results of my investigations regarding the use of okra fiber and the fiber of the cotton stalk as substitutes for jute in the manufacture of cotton bagging have been unsatisfactory and disappointing. The okra plant was cultivated for fiber in several localities this season, one field of 100 acres having been reported in Texas. As to results, I have nothing practical to report in the utilization of this fiber in manufacture, and up to the end of the year was not able to secure specimens even of the fiber, save in two instances, and from small experimental lots. Dr. C. F. Panknin, of Charleston, South Carolina, who planted a small area in okra, gives the results of his carefully conducted experiments as follows: A half acre of stalks was produced, one half of which when decorticated by his process, yielded at the rate of 180 pounds of fiber to the acre, the expense being in the neighborhood of $75. Regarding the cotton-stalk fiber industry, the Department has been unable to learn anything definite, further than the fact that small quantities of the fiber were prepared experimentally, last spring, from which about half a dozen yards of bagging were made, at a jute bagging factory in New Jersey. Considering the expense attending the harvesting of so branching and bulky a crop as both okra and cotton, where the stalks are coarse and woody, I do not see how the fiber can be obtained at a price to compete with fibers in present use, and therefore have serious doubts as to the success of either enterprise. The attempt to utilize the bast of the cotton stalk is no new thing, as experiments were made with the fiber years ago, and without success.

Out of the score of other bast fibers indigenous to, or that can be grown in the United States, there are several which may be regarded as promising jute substitutes, though careful experiments will be necessary to demonstrate the point of practical utility. These will also be treated in a special bulletin.

Several fine specimens of leaf fibers from tropical plants, including banana, have been received, and a few seeds of the manila hemp of commerce were imported during the summer and distributed in Florida and Southern California. In the latter State New Zealand flax is already growing, from which a good sample of fiber has been prepared.

During the year there has been a large correspondence in relation to fibers and fiber industries, and over five hundred samples of fibers have been received, these having been sent by farmers for identification and for information in regard to utility as well as by manufacturers or those interested in special processes or machinery.

On the whole the interest in fibers seems to be increasing, and it is hoped that much good will result from the work of the Department in this direction.

Respectfully submitted.

CHAS. RICHARDS DODGE,
Special Agent in Charge of Fiber Investigations.

Hon. J. M. RUSK,
Secretary.

REPORT OF THE SPECIAL AGENT IN CHARGE OF THE ARTESIAN AND UNDERFLOW INVESTIGATIONS AND OF THE IRRIGATION INQUIRY.

SIR: I have the honor to present herewith a report of the operations of the office conducted by me, under your appointment and direction, since the 15th of last April, when the artesian wells investigation first began, in accordance with the terms of a provision of an urgent deficiency act passed and approved April 4, 1890. On the 30th of September succeeding, by a provision of the general deficiency bill, the continuance to completion of that investigation was provided for, and to it was added also an examination of the sources and location of underflow waters found or to be located between the foothills of the Rocky Mountains and the ninety-seventh meridian of west longitude. The location and character of the artesian basins and wells were limited by the same boundaries. An inquiry into the cultivation of the soil by means of irrigation was by the act of September 30 also ordered and authorized.

WORK OF THE INVESTIGATION.

The necessity of completing these three extended investigations within seven months has kept the special agent, the engineer, and the geologist selected by the Secretary to carry out the same, with their small corps of field and office experts, exceedingly busy. One valuable series of reports, accompanied by maps, diagrams, and illustrations, is now ready for distribution. This is the report of the artesian wells investigation begun on the 16th of April and terminated as to its field work on the 1st of July, and as to the preparation of the reports thereof about six weeks later. The mere physical labor required to complete this arduous amount of work can hardly be realized. But although the limited time allowed by Congress for its accomplishment was insufficient for the attainment of entirely satisfactory results, it was utilized to the utmost extent by every one engaged. Over 70,000 miles in all were traveled during a period of ten weeks by the fifteen persons who formed the field staff. In the office organized by the Department 10,000 circulars and about 3,000 letters were written, mailed, and forwarded, answers being received to the extent of at least 50 per cent. Maps and diagrams were prepared, the work being in a field of observation almost unknown to the professional men engaged or to the scientific world itself. In the main, also, the staff required had, with the exception of the chief engineer and chief geologist, the field geologists and

two or three of the field agents, to be educated into the special requirements of the work performed. They have all done well and are deserving of commendation.

The two other inquiries ordered by Congress and which are now in progress have had the opportunity, so far as field work is concerned, since the 30th of September, of less than six weeks of weather in which out-of-door observations, engineering and geological, could be performed. It is impossible at this date to anticipate the reports on progress work which are to be made through you to Congress, but so much is known as to warrant the statement that these recent field labors will in their results prove to be of as great value as those of the midsummer investigations.

Two other reports, one a progress report on irrigation, the other a special series of papers on underflow and subterranean water, called for in June last by the United States Senate, are now in course of rapid preparation.

EXPERT AND FIELD STAFF.

The staff of the Artesian Wells Investigation was arranged into the statistical, engineering, and geological divisions. Besides the special agent in charge and his immediate force, it consisted in the field of the following gentlemen: Supervising Engineer Edwin S. Nettleton, of Colorado; Prof. Robert Hay, of Kansas, whose division geologists were the following: Prof. Garry E. Culver, State University, Vermillion, North Dakota; Prof. G. E. Bailey, State School of Mines, Rapid City, South Dakota; Prof. Lewis E. Hicks, State University, Lincoln, Nebraska; Prof. P. H. Van Diest, C. E., Denver, Colorado; and State Geologist E. T. Dumble, of Texas. The field agents were J. W. Gregory, Garden City, Kansas, who is known as the earliest advocate of the underflow theory as a source of irrigation supply; T. S. Underhill, North Dakota; Prof. S. G. Updyke, State Agricultural College, South Dakota; State Engineer F. F. B. Coffin, of the same State; Prof. Lewis G. Carpenter, who fills the chair of irrigation engineering in the Colorado State Agricultural College, had charge of eastern Colorado and New Mexico; and Frank E. Roesler, western Texas, with Mr. Horace Beach, special expert, comprised the field staff.

THE REGION EAST OF THE FOOTHILLS.

The area covered by the artesian wells investigation of the past summer and by the one now in progress embraces nearly 700,000 square miles of territory, of which 658,000 are found east of the one-hundredth meridian. This, in the central portion of the plains, passes along the foothills to the point where the Rio Grande enters Texas. From the northeast corner of Wyoming the foothills of the Rockies make a sweeping trend to the northwest, leaving east thereof nearly or quite two fifths of Montana. This area covers the States of North and South Dakota, over one half of Nebraska, Kansas, and Texas, all of Oklahoma, with the Public Land Strip, and about one third, east of the mountains, of Wyoming, Colorado, and New Mexico. The population of this region is now estimated at about 1,250,000 persons. The amount and value of the chief grain crops produced may be stated fairly as follows: In corn 185,000,000, in wheat 125,000,000, and in oats about 75,000,000 bushels. The average cash

value of all farm products grown within this area during the past year can be moderately estimated at $275,000,000. This does not include valuable fruit and wine crops raised in some portions of the arid region. The stock interests of the same area are of great importance and value. A fair estimate will give a total of 34,000,000 head of horses, cattle, sheep, and hogs, having a valuation of $366,000,000. These bald figures are sufficient to indicate the agricultural and pastoral possibilities of the region.

In this region the average or normal rainfall from the western Gulf section to that of the extreme northwest will range from 23.11 to 14.35 inches. On the western limit it will fall at El Paso, in Texas, and Fort Buford, in North Dakota, to an annual average of 10 inches, while at the ninety-seventh meridian the average will be from north to south about 21 inches. Within these long lines and parallels the dominant topographic and other conditions very seriously affect the degree of local—even of neighborhood—rainfall. This almost entirely treeless region is always liable during the most important weeks of summer to a dangerous deficiency of the precipitation needed to insure a good harvest. The soil is almost uniformly fertile, the sunshine is seldom wanting, and the normal temperature presents a fair mean, but the earth is desiccated by frequent droughts and the growing grain is devastated by the too frequent hot winds. Still, a careful analysis of the records shows that in this Great Plains and foothills section the annual precipitation is so distributed that at least one half, often more than that, falls within the growing and ripening months of May, June, July, and August. Following the lines of topography from north to south, as well as east and west, it will be seen that there is a wide difference in this respect between the semiarid or plains region and that of the arid domain proper—the intra-basin and Sierra Plateau table and valley sections beyond the Rocky Mountains—wherein it will be found that the rainfall is greatest during the fall and winter months.

Another and a most striking series of facts consists of those which relate to the formation of the Great Plains region, in connection with the distribution of the waters thereof, whether by surface channels or underground drainage. Their breadth from east to west is almost uniform, or about 500 miles. Northwest of 105° of west longitude the areas embraced within the artesian and underflow inquiries include broken table-lands or mesa formations, the wild irregular areas known as the "Bad Lands," and a large proportion of rugged foothills. The plains themselves have quite a uniform grade of from 3 to 20 feet per mile, ranging from east to west. The whole formation has a small "dip" from northwest to southeast. In considering the drainage of this great region, in both its present and future relations to the cultivation of the soil, this general "dip" and grade must be borne in mind. Unlike the narrow Allegheny plane along the Atlantic coast, this one of the transmissouri region is traversed only by a few shallow streams, whether these be narrow or broad in valley areas. They are all tributary to the Mississippi system; a majority are direct branches of the Missouri; but the Arkansas and its tributaries flow into the Father of Waters itself. This river system from northwest to southeast, forms the important western feeders of the Mississippi River. Along the southwestern border of the plains region the Rio Grande, having a wide and open valleyway for less than 400 of its whole course of 1,200 miles, passes from the Saguache and San Juan ranges in southern Colorado, through mountain cañons,

open parks, broad valleyways in Colorado and New Mexico, until receiving the Texas tributaries in the midst of a wild cañon region, it finally reaches the open alluvium bottoms and is lost in the Gulf of Mexico a few miles below Brownsville.

The infrequency of river courses in the region we are investigating is a momentous fact which must always be borne in mind. The State engineer of Wyoming, Mr. Elwood Mead, estimates that there falls annually upon the great mountain range of that State, a precipitation of snow equal to 60,000,000 acre feet—that is, 60,000,000 acres covered 1 foot deep with snow. Allowing one third for evaporation and one third for drainage, there remains in Wyoming 20,000,000 feet of such snow precipitation, or that number of acres covered 4 inches deep by water. Evaporation is generally considered to be equal to one third of the total amount of fall. It may well be questioned, however, whether such be the case within the temperate regions and at such high altitudes. Sufficient rain falls also during the year to make the annual average not less than 15 inches of water. To estimate this vast amount of moisture in the ordinary language of our eastern agriculturalists, by gallons or barrels, will present an array of figures almost impossible for the human mind to grasp. Allowing for evaporation upon the mountain summits and slopes to the extent of 25 per cent, it will be fair upon entering upon the open plains region to allow for a loss of 30 per cent from the same cause. It will thus be seen that there remains unaccounted for at least 45 per cent of the total annual precipitation. It does not need a special training to perceive that this great loss from the surface water disappears into the earth itself. Of the evaporation into the atmosphere, the major portion of the moisture taken up must at some place and period, return to the surface of the earth. But this is not the case with that which torrentially or otherwise disappears below that surface.

Here, then, is the problem which the investigations of last summer and autumn are endeavoring to solve. Taking into consideration the topographic and hydrographic features of the whole region, knowing something of the climatic conditions that affect the distribution of waters therein, observers, engineers, and geologists must naturally be disposed to consider the restoration of the underflow, artesian, or phreatic waters, a project of the most serious importance, but one which is not met at the outset by any stupendous outlay or vast difficulties in the way of engineering work. It is not necessary to deny the need of storage works at some not distant day; it is only desirable to consider the means by which security to agriculture may *now* be obtained and how the development of this region already so well begun can be made of a permanent and prosperous character. The labors of the past seven months have brought together such a mass of facts and testimony as to show:

(1) That over a major portion of the region designated by law to be investigated, the rainfall, if it could be distributed when most needed, is almost if not quite sufficient for ordinary agriculture.

(2) That the period of serious deficiency during the year is confined as a rule to within a few weeks of the summer time.

(3) That the conditions affecting the phreatic or drainage waters of the region, are even now sufficiently known to warrant the statement that these waters may readily be recovered, and in connection with the storage, distribution, and use of surface streams, afford a reasonably sufficient supply for at least two thirds of the area under consideration. It must also be borne in mind that such earth-waters

are replenished every season. The experience of southern California establishes this, as so excellent an authority as Prof. E. W. Hilgard virtually maintains.

The map accompanying this report shows the location of 1,300 artesian wells now bored and flowing from north to south, between the ninety-seventh and one hundred and fifth meridians. Speaking broadly, it may be asserted that the artesian basins, which these several wells have penetrated, present, when the facts are collated, a striking similarity of conditions. The depth, taking elevation into consideration, will be found almost uniform. The pressure, volume, and temperature, of their waters all bear a striking resemblance. The geological formations are intimately related to each other, and in the northern half of the region are entirely similar. The chief variance from this statement will be found in the Denver artesian basin, which is probably fed by secondary rather than by primary or deep drainage; also in the tertiary basins of western Kansas. No area in the world presents so large a present and possible supply of artesian water, and none yet known to us covers so wide a range and embraces such a large territory.

The report of the Artesian Wells Investigation, as well as the supplemental report, called for by the Senate in June last, will show other sources of supply from earth waters which are sure to prove of great importance to the farmer and cover an area even more important than that which can be supplied by artesian wells proper. Mr. J. W. Gregory, field agent for the central division of this investigation, deserves the credit of being the earliest to present systematically the existence of a large water supply at very moderate depths below the surface within the valley regions that traverse the Great Plains. Living at Garden City, Kansas, in the Valley of the Upper Arkansas, this gentleman, affected by the climatic conditions which threatened the ruin of so promising a community as that in which he resides, begun several years ago to take notice of the facility with which water was obtained throughout that broad valley within from 5 to 40 feet of the surface. As settlement progressed in western and southwestern Kansas, varying in progress with the wet or dry seasons, Mr. Gregory's observations became extended to the prairie lands beyond the valley. Taking the general grade of the country, its rise toward the Rocky Mountains, the great amount of precipitation known to fall upon the higher summits thereof, and, relating these observations to the volume of water at various periods found in the channel of the Arkansas, Mr. Gregory became convinced of the existence at moderate depths below the surface and according to the elevations thereof of an almost continuous drainage supply, which he has termed the under-sheet or under-flow water.

At the same period a series of close observations had been made under the direction of State Engineer Nettleton, of Colorado, now the Department's chief field engineer, into the seepage or percolation of irrigation ditches and as to what became of the water thus disappearing in the earth. The observations of Colonel Nettleton and his assistants, as well as of other experienced persons in Colorado, soon established beyond dispute the fact that the waters thus disappearing in the canals and ditches that irrigate large areas in northern and central Colorado reappeared in the channels below at such distances as proved that the gravel strata just below the alluvium forms an admirable water bearer and conveys this ditch seepage to

the point at which the grade admits of its reappearance on the surface. There are numerous facts not yet properly collated which go to prove that the cultivation of the soil through irrigation must by means of the capillary attraction attached to the plant roots necessarily bring to the surface a large supply of the minor phreatic waters. Springs are known to break out where before none existed within such irrigated areas. The humidity of the night condenses itself under the fall of temperature into what is called "dew" for want of a better definition. Before cultivation and human habitation no such phenomena were there observable. This humidity is doubtless due more to increased moisture in the earth than to any additional supply in the atmosphere. It is claimed also, and with considerable force in Colorado and Wyoming, that these facts and many others not yet fully examined point conclusively to the truth of the declaration that irrigation means no final loss of the water supply to the farming communities lower down the stream. They point, however, even more forcibly to the necessity of a thorough examination of the western part of the Great Plains region from north to south, with a view to a reasonable ascertainment of the character, quantity, and availability of the upper drainage waters, which are constantly being fed from high-altitude mountain sources, and which by reason of the topographical formation may, it is believed, be made easily accessible to the use of farmer, horticulturist, and cattle-grower.

CONCLUSIONS OF THE SUPERVISING ENGINEER.

The supervising engineer, Edwin S. Nettleton, upon taking the field in April last, decided to begin work in North Dakota and proceed southward. A topographical survey was found unnecessary, railway elevations being found numerous enough for accurate levels. In the series of questions framed for the obtaining of geological data, the one relating to the depth and the geological strata passed through was almost wholly unanswered. This important failure has been one of the real difficulties of the investigation, the total depth being in general the only record kept of the well. The agents and officers of the Department obtained the pressure of many wells by the aid of gauges furnished them. This pressure was generally given as so much per square inch when the flow was shut off. The larger wells were measured by passing the water over a weir. Within the James River Valley basin the supervising engineer found about 150 wells, scattered over a territory more than 400 miles in length from north to south and from 40 to 50 miles in width. A number of failures to find flowing water in rock-bored wells has occurred along the eastern line of this valley. West of this land all borings have been successful when made deep enough to penetrate the Dakota sandstone. This sand rock, composed of a soft, porous, light-grayish stratum of unknown thickness, has been penetrated 80 feet without reaching its lower bed. In many places the drill goes down by its own weight. The "dip," as shown by the records of this water-bearing stratum, is toward the north. On a line from Yankton to Devil's Lake the "dip" is 830 feet, being about 2.3 per mile, while the surface trend towards the south and east is on an average of eight tenths foot per mile. At the top of the wells the pressure ranges from 20 to 167 pounds to the square inch. The area of greatest pressure so far as now determined from existing wells lies in the

central portion of South Dakota. The greatest pressure in water-bearing stratum is near Jamestown. All surface indications and outcroppings point westward for the source of supply.

The wells now in use have in a majority of cases been active for the last 5 years without diminution of pressure. Engineer Nettleton regards the Dakota basin as the largest and strongest artesian supply yet discovered in the world. The wells maintain a flow quite near to that which is due to the hydrostatic pressure minus the loss of force by friction in passing through the pipe. Nearly all of the Dakota wells throw out large quantities of sand. This is a fact which is taken by some of the drillers to prove that the water-bearing stratum is simply loose sand. Observations of pressure and reliability of flow show that the water must have a free and considerable movement through the stratum so that the pressure reaches its maximum almost the instant the wells are shut off. The engineer regards the indications seen at Waco, Texas, and its vicinity as proofs of another important basin, which the want of time made it impossible to fully examine. A very notable fact about this basin is that the water-bearing stratum lies over 1,800 feet below the earth's surface, and at least 1,200 feet below the level of the Gulf. The pressure at the Waco well indicates that its supply must also come from a loose and porous rock. A third important basin now in process of development, but just west of the foothills line, is found in the San Luis Valley, Colorado, where many hundred wells of comparatively little depth have been bored or drilled during the last twenty months. Several thousand acres were irrigated by the water of these wells during the season of 1890. The supervising engineer sums up the following as presenting the more important results of his investigation:

(1) The existence of a large artesian basin in the Dakotas, which is indicated by the number of flowing wells scattered over an area of about 12,000 square miles.

(2) The presence of an abundant supply of water in a loose sand stratum of great thickness and subjected to great pressure, which is fully maintained after being pierced by numerous wells flowing their full capacity for years.

(3) The probability of an extension of this basin to westward or a considerable distance from the James River Valley developments and having similar characteristics.

(4) The probable existence of an artesian basin in Texas similar to that in the Dakotas and of unknown area, but lying at a greater depth from the surface.

(5) The existence of several artesian basins in other parts of the country examined, which have similar flows, from which water is obtained in sufficient quantities for domestic use, and, in some instances, for the irrigation of small areas.

(6) The existence of two artesian basins lying in the drift, where flowing water for domestic use and for irrigation is obtained at a very low cost.

(7) The necessity of irrigation to prevent total loss of crops at times and for their full development nearly every year.

(8) The existence of large supplies of subterranean waters underlying quite generally the whole territory examined.

(9) The lack of knowledge of the majority of the people of the methods for utilizing the artesian well and underground waters for irrigation purposes.

(10) The need of a closer and more extended geological examination to designate, as near as possible, where it is probable that water may or may not be obtained.

(11) The necessity of verifying by test experimental work some of the conclusions of the geologists.

(12) The necessity of investigating the subject of utilizing the subterranean waters and the extent of country which can be reclaimed by them, and to report on methods for bringing such waters to the surface and the cost therefor.

THE GEOLOGICAL RECONNOISSANCE AND RESULTS.

Prof. Robert Hay, F. G. S. A., chief geologist of the Department, who was in charge of that branch of the field work during the summer past, presents the following as the problems to which he sought to obtain intelligent solutions:

(1) In the region under examination are there any artesian wells now used for irrigation?
(2) If so, are the wells so used in groups or isolated?
(3) Are any of the wells available for irrigation to a larger extent than at present?
(4) Can the areas in which existing wells are found be defined and their geologic conditions determined?
(5) Are there other areas whose conditions are similar where artesian water may probably or possibly be found?
(6) May the areas already known be expected to yield more water with further exploration?
(7) In what way are the phenomena of springs and the subflow of river valleys related to the conditions of artesian wells, and are the springs and subflows available for irrigation?

As a result of the inquiries made in the direction indicated, Professor Hay relates, geographically and otherwise, the artesian basins examined in whole or part, as follows:

(1) The wells of the Red River Valley in northeastern North Dakota.
(2) The wells of the James River Valley in the two Dakotas (North and South).
(3) The wells of the Yellowstone Valley at Miles City, Montana.
(4) The shallow wells in the drift formation on the eastern side of the two Dakotas.
(5) The wells of northern Nebraska.
(6) Four groups of wells in southwestern Kansas.
(7) The wells of the La Pondre, Denver, and Pueblo basins in Colorado.
(8) The Fort Worth and Waco groups in Texas.
(9) The wells of New Mexico.
(10) The wells of Wyoming.

The group numbered 9 represents attempts rather than wells. Since the preparation of his report, however, a successful artesian well has been bored at a point 6 miles south by east of Springer, in northern New Mexico, the water from which is now flowing. In the first three groups named Professor Hay claims that a considerable portion of the flowing waters from their successful artesian wells can easily be made available for irrigation, and that, too, at no great cost. The remaining five groups consist of flowing wells under greater or lesser pressure. The geologist places the total number at 1,400, of which about 350, mostly in Texas and Colorado, now require pumping to bring the water to the surface. This cessation of flow is due according to Professor Hay to the boring of too large a number of such wells within a too limited area. The fact, in his opinion, points to the necessity of local legislation in order to prevent too great a continuity of wells, especially where the waters of the same are likely to be used for irrigation purposes. It may be stated here that this necessity has been found imperative in San Bernardino and Los Angeles counties, California, where several thousand wells are in use for domestic, stock, garden, and orchard usage and irrigation. Local ordinances require the capping of all wells when not strictly in use for beneficial purposes. They also compel the shutting off of the water, at certain periods, of groups of wells, so that the supply for others may be equalized. All these point, it is claimed, to the conclusive necessity of considering all subterranean waters from which the artesian wells are supplied as part of the natural supply to be utilized under regula-

tion for the common benefit. In all arid regions natural waters above or below the ground are commonly regarded as public property, subject to regulation and control. The means of reaching, storing, and distributing, may or may not be of the same character, according to the will of the communities in which they are found.

The chief geologist does not consider that the James River Valley is connected with the artesian supply of the Dakotas in the direct way of cause, nor does he believe that it "limits the area of the real artesian trough, which is a deeply seated synclinal fold, whose axis is approximately north and south, and whose eastern edge is hidden in eastern Dakota by later accumulations of the drift period, while the western rim is upturned on the eastern flanks of the Black Hills and the more distant mountains of the Upper Missouri." Professor Culver, who served as the Dakota field geologist, believes from the records of the wells which he has studied that the impervious beds that overlap the pervious sandstone to the east seal in the waters on the low edge in that section of the artesian basin and thus prevent their escape. On the southeast boundary of the Dakotas, however, this overlap does not take place, and the waters escape in springs along the Iowa border, so that the pressure from the wells of that section of South Dakota is much less than further north in the James River Valley. From the geological indications Professor Hay considers that artesian water should be had from the same sandstone very much further to the west and northwest than has yet been tested. It is pointed out, however, that on the great Sioux Reservation the valleys thereof are so deeply eroded as to make it probable that the water-bearing sandstone may be reached at much less depth than is the case in the northern parts of the James River Valley. It is notable also that in Wyoming, on the western side of the Black Hills, the same sandstone formation yields flowing wells of salt water, bearing also oil and gas in considerable quantities. Professor Bailey makes note of sixty of these wells. The extent of this wonderful geological formation may be realized when it is remembered that in southwestern Kansas and southeastern Colorado, just over the line and below the Arkansas Valley, there is found a group of artesian wells which derive their waters from the Dakota sandstone. The same formation outcrops in eastern Nebraska and central Kansas, giving further evidence of its large water-bearing capacity. Professor Hay does not believe, however, that the supply in these States is derived directly from the drainage of the foothills of the Rockies. A geological change occurs in the sandstone corresponding in latitude with southern Nebraska and northwestern Kansas by which, according to the professor, there is a metamorphic change into quartzite, through which the Dakota stratum loses thereby much of its permeable quality.

In the eastern part of the Dakotas, as well as elsewhere to the south throughout the Great Plains, Professor Hay calls attention to a number of wells of much less depth, pressure, and flow than those which derive their supply from the Dakota sandstone. They obtain their water from gravel and sand belonging to the glacial drift, a sheet of which from 15 to 200 feet thick was found beneath the alluvium at moderate depths. When this glacial drift is covered with clay the water is sufficiently confined to make an artesian flow of at least the negative quality. It is less mineralized and cooler, says Professor Hay, than the artesian water. The artesian basin in and around Denver, Colorado, presents geologic conditions which

deserve close study. Their supplies are received from formations much newer than the sandstone. The probability of finding similar waters in Eastern New Mexico is also favorably considered. Since the summer investigation a large amount of data has been obtained in relation to the possibility of obtaining water in this region by means of bored and drilled wells and through the utilization of an enormous area of natural waters which flow with artesian force to the surface in the form of springs. No attention has heretofore been given except in the way of noting the same on the maps of the public-land surveys, to the extended area, abundance and great volume of springs which are found from very near Arkansas River southward and beyond the center of Texas turning eastwards, and to indicating the pressure of waters flowing from subterranean sources as it breaks out along the southern flanks of the superimposed Staked Plains region.

A very interesting portion of Professor Hay's observations and reports relates to the water-bearing capacity of what he terms the tertiary grit, a formation largely underlying the plains region of western Kansas, and conspicuous also over a large area in eastern Colorado and New Mexico, and in a large portion of western Nebraska and Texas. It is from this tertiary grit that the numerous springs referred to are taken. Many of them may be tapped, says Professor Hay, above their present outlet, and be made available also for irrigation. The geologist regards the observations made as showing that in the subarid region investigated there are at least five water-bearing formations of different geologic ages. "In descending order they are: The Glacial drift; the Tertiary; Laramie; Dakota sandstone; and the Triassic red beds." Professor Hay's chief conclusions are as follows:

It is highly probable that known artesian areas will be greatly extended by further exploitation.

It is certain that some of the areas as already defined may have many more wells than now exist without reducing the supply of water.

The diminished supply, or rather the loss of force to the extent of wells ceasing to flow, at Fort Worth, in Texas, and at Denver, Colorado, is a warning that should operate to prevent the clustering of wells too closely together, even where there is an ample supply of water.

He adds that—

The phenomena of springs which may be defined as natural artesian wells form a necessary part of the things to be examined, as they suggest limits within which artificial artesian wells can scarcely be expected, besides the fact that such examination of springs may lead to their utilization in irrigation.

The sandy nature of formations which in a large part of the plains region are noted for their water-bearing capacity is the main cause of the conditions which allow some of the river valleys to have a subflow of water equal to or perhaps greater than that of the visible streams. The conditions of hydrostatic pressure under which the subflows exist suggest that their phenomena are directly related to those of artesian wells and springs, and may properly be investigated with them.

THE DAKOTA ARTESIAN BASIN.

The vast extent of the Dakota artesian basin has been testified to by the inquiries and deductions of the engineers and geologists. Even a slight acquaintance with the chief features of the physical geography of the Dakotas strongly points to the probable permanency of the water supply. The western mountain drainage flow penetrates below the superincumbent stratum to the body of friable rock known as the Dakota sandstone. It is evident that the drill

has nowhere penetrated more than a few inches of this water-bearing and conserving stratum. The altitude, the general trend of the land, and the formation and character of the great hydrological or river area which intersects it, give weight to the deductions that are made as to extent and permanency. There are found within it over one hundred and fifty high-pressure artesian wells, including, with those in the Dakotas, the few bored in the Yellowstone Valley of Montana. There are also found in South Dakota several hundred flowing wells, whose supply is evidently from sources not identified with the greater artesian basin. In northeast Dakota, in the hydrological basin of the Red River, claimed by geologists to be the seat of an ancient lake, there are nearly a thousand small flowing wells, whose waters are used largely for farming and stock purposes, as also in garden and other small irrigations. No diminution of pressure is anywhere reported. The source of their supply is from the upper beds of glacial drift. The people who have settled in the Dakotas belonged originally to States wherein the practice of irrigation is unknown. Active settlement began in these two new commonwealths during years that were blessed with considerable rainfall. A few years more, however, have proven conclusively that the element of insecurity as to rainfall is really a permanent one. It would be folly to deduce from such a short period of years as that in which observations have been taken any theoretical dictum claiming authority for its statement; but it is evident, not simply from climatic observations in the Dakotas, but from those taken throughout the Great Plains region, and extending over a much longer period, that there is something like a periodicity of abundance and drought, covering, so far as can now be deduced from observation, cycles of from seven to nine years in duration. Another, and perhaps even a more important feature for the establishment of agricultural security in the Dakotas as well as elsewhere on the Great Plains, is involved in the possibility of realizing a more equitable distribution of the rainfall, and it may reasonably therefore be assumed that over a large portion of the area under consideration the annual rainfall is almost or quite sufficient, if it could be evenly distributed as to area or controlled in its fall as to time. The fact remains that there is no equality in the distribution either in area or time.

Evidence tends to show that human industry applied to the land has already greatly modified the phenomena of distribution. Naturally enough those who have observed such features have hastened to the conclusion that these modifications tend also to a permanent change of climate. It may, however, safely be assumed that so much of this conclusion is correct as warrants a belief in the modifying and ameliorative effects, locally speaking, of human industry upon our semiarid soils and region. What the farmers of the Northwest desire and what they need is development of the water supply which lies beneath their feet, and which they may find immediately at their gates. Over the eastern half of the twin Dakotas they are not absolutely dependent upon irrigation. For industrial security, however, they need the power to draw upon supplies stored in wells or reservoirs. The harsher and larger climatic conditions at their period of need prove too often destructive of all their labor and its results. Such a supply as will meet this want, not large, but imperative in character, seems to be at their command in the wonderful artesian basins that unquestionably lie within the borders of

the two great States, and which will probably be found to also serve a considerable area of northern and eastern Montana.

The people who had settled within this new northwestern section, and who have recently brought to the Union five great and important commonwealths, have paid into the Treasury of the United States for the public lands they have reclaimed and made fertile from $35,000,000 to $40,000,000. In the Dakotas alone the total of land payments exceeds $25,000,000. By adding the great sums paid by settlers to land-grant corporations we shall have, in all probability. a total of $35,000,000 for the Dakotas alone. A great net-work of railroads has already been constructed, and prosperous towns and villages have already been founded by the hundred. The Dakotas are famous in the markets of the world for the production of wheat. The commerce of the nation has been greatly increased by the growth and shipment of this its particular and valuable grain.

The popular feeling in the Dakotas, especially south of Devil's Lake and west of the Red River Basin, has settled during the progress of the investigations into a public opinion, which asks of the General Government a full and comprehensive investigation of the limits east and west, north and south, of their remarkable artesian basin. It is urged that this investigation does not involve the necessity of a protracted topographical survey; that the altitude and other physical features of the country are all well established and known; that the work of the geologist and engineer can necessarily be confined to a reconnoissance of the country in which the outcropping and the altitude both afford proof sufficient to warrant the belief that therein will be found the western limit of the water-bearing basin. The people interested are unanimous in asserting that the one important help they now require is the sinking and boring by the General Government of a range of experimental wells westward from the James River Valley, such as will show to the settler and private capital the possibilities involved and the practicability of obtaining at moderate cost the artesian waters known to exist. With such help these communities assert their ability to obtain capital by which to enable the counties and towns of each State to purchase machinery to sink wells and to construct storage reservoirs, sufficient in number to make secure their present great agricultural possibilities and enable them to maintain the homes which as pioneers they have won from the wilderness. The reports of Engineer Nettleton and Geologist Hay, as well as a thousand confirmatory facts and observations, all tend to strengthen the views so generally expressed by the people of the Dakotas.

During the past year, and largely since the action of Congress in appropriating $20,000 for the first investigation, great activity and interest have been manifested in this matter of water supply. In South Dakota a considerable number of wells have been sunk or are now in process of being drilled. Inspiration to such investment and effort has arisen largely from the presence of the Department agents in that region, and through the great discussion in progress over the questions of artesian and underflow supply. Under a law passed by the first State legislature of South Dakota, as an amendment to one passed by the territorial legislature, the counties are permitted to issue bonds for the raising of money wherewith to pay for the sinking of wells. In some of the more populous counties already large preparations are being made for the purpose—one, the county of Brulé, proposing to spend in all about $1,500,000 for this purpose.

During the past summer, under the encouragement afforded by the practical teaching and experience of Engineer Nettleton, as well as by the current discussion, several efforts were made to irrigate small areas of land by water from artesian wells. About 500 acres have been so irrigated. In several instances the reports made to the Department, through the office of irrigation inquiry, show results of most encouraging character. The yield on the land irrigated has been from ten to fifteen times as great as on unirrigated portions of the same field or farm. Within the States of North and South Dakota, by water from negative artesian wells (in the Red River Basin in Miner and Sanborn counties), there are now about 3,000 acres under irrigation. This excludes the southwestern portion of South Dakota, known as the Black Hills, in which irrigation by ditches and from surface streams is already quite extensive, embracing about 15,000 acres. Evidence comes from this region as to the practicability of reënforcing the surface supply by extensive drainage deposits.

THE DAKOTA TOWN WELLS.

As an illustration of the extent to which the artesian and underflow waters are utilized in the Dakotas, the following tabulation of water works completed for town purposes within the States of North and South Dakota up to the beginning of 1890 is herewith annexed. During the past year ten or twelve additional town systems have been put in operation.

NORTH DAKOTA.

Town.	County.	Source of supply.	Diameter of well.	Depth of well.	Flow.	Pumping machinery, daily capacity.
			Inches.	*Feet.*	*Gallons.*	*Gallons.*
Ellendale	Dickey	1 artesian well	6	1,087		
Oakes	....do	1 artesian well (flowing).		853		
Devil's Lake	Ramsey	1 artesian well		1,520	35,000	
Fort Totten	....do	Spring				48,000
Jamestown	Stutsman	1 artesian well (flowing).		1,500		
Grafton	Walsh	1 artesian well		912		1,500,000

SOUTH DAKOTA.

Town.	County.	Source of supply.	Diameter of well.	Depth of well.	Flow.	Pumping machinery, daily capacity.
Plankinton	Aurora	1 artesian well (flowing).		545	(*)	
Huron	Beadle	....do		863	1,500,000	
Scotland	Bon Homme	1 artesian well				
Tyndall	....do	....do	4½	735		
Aberdeen	Brown	2 artesian wells (flowing).	5½ (†)	906 1,000	3,000,000	
Columbia	....do	1 artesian well (flowing).				
Andover	Day	1 artesian well				
Mitchell	Davison	2 artesian wells (flowing).				1,000,000
Faulkton	Faulk	1 artesian well (flowing).		1,210		
Miller	Hand	... do	6		3,900,000	
Highmore	Hyde	....do				
Spearfish	Lawrence	Springs			(‡)	
Salem	McCook	Well		225		50,000
Rapid City	Pennington	Spring §				
Woonsocket	Sanborn	1 artesian well (flowing).	6		(‖)	
Doland	Spink	Dug well	4½ feet	937.5	850,000	
Mellette	....do	1 artesian well (flowing).				
Redfield	...do	....do				

* Two gallons per minute.

† Six and one half inches at top and 4½ inches at bottom. Used for water works, sewage pump, and for fire purposes. Two other town wells being bored.

‡ Average daily flow 209,455 gallons.

§ Reservoir capacity 400,000 gallons.

‖ Daily yield 3,000 to 6,000 gallons.

THE CENTRAL PLAINS AND THE UNDERFLOW REGION.

One of the most remarkable of the series of facts which the investigation has so far brought together relates to the existence of great deposits of drainage water at a moderate depth below the alluvium, the existence of which supply has so far been quite well established at different points within the central division of the Great Plains, embracing a large portion of western Nebraska and eastern Wyoming, as well as the greater portion of western Kansas and eastern Colorado, with a considerable area in the Indian Territory and the adjacent section of New Mexico. It is also demonstrated, through the actual finding of water at moderate depths, to be underlying the moderately elevated plateau or table-land known in Texas as the "Staked Plains." Without doubt investigation will establish the same condition in the Panhandle region of that State. This phreatic supply differs in degree and perhaps in volume from that which is found underlying the surface in the wide regional river valleys, such as the Platte, the Arkansas, and Cimarron. The substratum, permeated by the percolating flow of the rivers, is largely composed of sand, the movement through which, although continuous, must be much slower than that through the looser gravel stratum. The continued rise westward at a steady grade per mile has induced the engineers and canal owners within the upper Arkansas Valley to construct works for the utilization of this great body of undersheet water. Such works are already in partial but successful operation at Dodge and Garden Cities in western Kansas. The owners of the Eureka Canal are fully expecting to supply that large irrigation ditch with water from the subcanals and reservoirs that have been constructed at and near Dodge City. Similar works are now in process of construction in the valley of the North Platte, Nebraska. A number of submerged dams have also been successfully constructed and operated at points in Colorado, by means of which the flow of streams otherwise diffused and lost below the surface has been successfully stored and utilized for irrigation and other domestic purposes. Civil Engineer Van Diest, of Denver, who was in charge of the geological examination of eastern Colorado and New Mexico, in closing his valuable report has the following to say in regard to both artesian and underflow waters and their relations to irrigation uses:

The artesian flows are means for transfer of water from high humid regions to more arid tracts.

The advantages of such process over transfer of water in irrigating ditches are that it costs nothing, that there is no loss by evaporation and seepage, and that the supply is uniform and practically independent of a dry season.

The hydrostatic pressure forces the supply to a point where the water is needed, provided a communication is made between the underground flow and surface. If the depth of water supply is not too great the cost of boring will in many cases be less than the cost of bringing the water by long ditches to the land.

The limit of depth to which boring for water can advantageously be undertaken is largely dependent on the amount of supply that can be obtained and on the kind of crop that can be raised on the land to be irrigated.

It will pay to bore to a considerable depth for the irrigation of fruit trees and garden truck when the flow is small, while for raising wheat it may not pay to bore at a moderate depth, even when the flow is large.

The utilization of artesian flows has a great disadvantage in the many requisites of a flowing artesian well. Only at a few places in eastern Colorado and New Mexico are these several conditions so happily combined that artesian wells are cheaper means of irrigation than by lateral distributing from surface ditches. Another drawback is that artesian wells must necessarily be bored at lower levels

than the collecting area, and consequently are not beneficial at points located higher than can be reached by ditches. On these grounds the artesian well can never become a very important factor in irrigation in Colorado and New Mexico, but it may be in many places a great benefit when the water supply from other sources is small.

In eastern Colorado, where the climatic conditions and the soil limit agriculture to cereals, an artesian well does not give a sufficient supply for so large a tract as such a culture requires to become profitable. It is, however, an excellent auxiliary to the efficacy of the ditch. The farmer who has an artesian well in addition to his ditch lateral has an advantage over his neighbor similar to the advantage in the time before the opening of the Suez Canal of the Indian merchantman with auxiliary steam-power over the sailing vessel for weeks becalmed within the tropics.

The utilization of underground flows without hydrostatic pressure is not so limited as the utilization of the true artesian flow. The collecting area of this kind of subterranean flow is in eastern Colorado and New Mexico vastly greater than of artesian flows; they occur at less depth, and although they have but feeble or no pressure and must be raised artificially to the surface they can be forced in great volumes to points higher than ditches from neighboring streams could reach. The possibilities of bringing productiveness to a large area of arid land by the utilization of these underground flows are great. They may become in the future very important factors in the work of irrigation, and deserve a closer and more detailed investigation than the very limited time of the present investigation allowed to devote to this problem.

Mr. Van Diest has paid great attention to the science of hydrology and has had a remarkable experience in the construction and direction of hydraulic work related thereto, having served as engineer in Holland (his native country), France, England, Java, India, Japan, and in the United States, of which he is a citizen.

Observations made by Professor Hilgard, of the University of California, strongly confirm the practical experience which has shown already in Colorado and elsewhere the extent and feasibility of this great underflow supply. As great an authority as Prof. T. Sterry Hunt declares that 1 square mile of sandstone 100 feet thick will contain, when thoroughly saturated, water enough to flow continuously 1 cubic foot per minute for a period of thirteen years. Pure sand when saturated contains from 30 to 40 per cent of its bulk in water, while the more porous gravel will hold 25 per cent, with certainly a freer space for the element to move in. In sandy soils, which are always porous, the water will rise or fall with the temperature and the changes of climate. A fall of 6 feet to the mile, and that of the rivers on the central plains is much greater, may give from saturated sand and gravel a steady discharge of from 40,000,000 to 50,000,000 cubic feet per square mile.

A cubic foot of fine sand it is estimated will contain 2 gallons of water, of coarse sand 2½ gallons, of sand and fine gravel 3 gallons, while a cubic foot of coarse gravel and small stones will contain about 3¼ gallons. The porosity of sand is equal to abont one third its cubical volume. To 1 square yard of quartzoid sand 33 per cent of water can be added; to marl can be added at least 15 per cent of water. Clay, when dry, will absorb about 12 per cent; loose gravel, sand, and small stones will take up from 15 to 20 per cent of their space in water. Given these conditions and keeping in view the contours of the earth and the vast topographical features of the great region under consideration, it may be readily perceived that there is a great deal more than hypothesis or conjecture in the underflow proposition. Indeed the array of data and of facts already collated presents such an amount of proof as to justify the conviction that everywhere throughout the arid and semiarid regions it will be found over very large areas to be a prospective source of water sup-

ply of great industrial importance. Already large and prosperous manufactories of pumping and lifting machinery have been established, and among the papers that will be embodied in the supplementary report on underflow will be found a report from the manager of one of the most important of these new enterprises.

THE ECONOMIC IMPORTANCE OF THE INVESTIGATIONS.

It is probable that no one has seriously considered what is meant by an outcry against encouragement to irrigation and the investigation by the General Government and by this Department of the sources of supply of water in the arid region. Antagonism has been unquestionably expressed and from unexpected sources. It has been assumed that the growth of irrigation will rapidly tend to increase a disastrous agricultural competition in the markets of the continent and the world. In the progress of the investigations ordered by Congress this line of discussion has been met at nearly every turn. As it is founded on misapprehension it may be well to show what are the real forces at work to justify further inquiry and a continued examination into the general results of irrigation.

In the first place, no outcry is likely to prevent the movement westward on the unoccupied territory of our people. Whether such movement be wise or not it continues to go on. Ten years since it was declared on high authority that not over 11,000,000 acres of arable land remained east of the one hundredth meridian, and that west thereof a very small proportion of the whole area could be brought under cultivation. Yet since the publication of this statement more than 50,000,000 acres have been taken up for farming purposes, and a considerable proportion of this area has raised heavy crops of large and small grains, vegetables, and other products. At the present moment about 9,000,000 acres of land, considered worthless in 1880, are cultivated by means of irrigation. The forthcoming reports, preparing under your direction, will include some striking tables of land values, showing an increase of from 100 to 500 per cent in the market price of arid lands made fertile by the artificial distribution of water. But the great economic fact which replies to all the fears of competition is to be found in the rapid growth of industries other than that of agriculture that inevitably follow the reclamation of considerable areas of our arid lands. The railroad construction proceeds and accompanies such reclamation. The capital invested therein brings other capital to aid in the development of the country; markets grow about the railroad centers; mines are opened and manufactories established; towns are built; while the production created by means of irrigation must largely prove to be not of a competitive character, so far as our continental markets are concerned. It is virtually, under almost all circumstances, the creation of new products and industries. The development of our mineral wealth with the progress of arid reclamation will be conducted on a scale and with a certainty heretofore unknown. The intramountain valleys and basins, generally limited in extent, in which water can be obtained for agricultural uses will become the neighbor of the mine and the supporter of the prospector and miner. The average food products so raised will be consumed at home. But it is not in the direction of average products that the wealth-making benefits of irrigation, applied to the soil for the purposes of cultivation, will usually be found. It is not necessary to consider here the character

of soil and climate within our arid domain. The facts, known of all men, are such as to prove not only where irrigation is practiced that ordinary crops can be produced with greater certainty, but that, in a much larger degree, the land so cultivated will be devoted to the raising of special crops that, in the main, will supplement and not compete with the Eastern farmer, bringing high prices to the producer and adding new wealth to the nation.

The experience of California and Colorado clearly demonstrates the truth of this presentation. Seventeen years ago the San Joaquin Valley, in California, was a desolate waste, given over to the jack rabbit, the horned toad, and the broad-horned steer, whose subsistence required from 15 to 25 acres of wild land per head. Very little wheat, hardy cereal as it is, could be grown in Merced, Fresno, or Kern counties; that of Tulare is better adapted to wheat raising. In 1874 the first colony life began in Fresno County, an area larger than some States and containing 5,600,000 acres. At the date named some 500 poor settlers located in and around what is now Fresno City. Now 20 different canal systems are in existence. Sixteen hundred vineyards make it the largest center of raisin-grape culture in the world. There are now over 30,000 people in and about that city, whose settlement began in 1874 with less than 500 colonists, while the county has over 100,000 population. The area devoted to the cultivation of grapes is 49,086 acres, of which 27,188 are in full bearing and 22,280 are devoted to the raisin or Muscal grape. The increase during the past year has been quite one fourth of the total area given. The value of this new industry, manufactured by sunshine and water out of the desert soil, is to Fresno County alone not less than $4,000,000 a year, while nearly as much more is created elsewhere in the State of California. Besides the vineyards there are 20,000 acres in orchards, mostly devoted to semitropical fruit. Of this area 300,000 acres are also devoted to the cultivation of wheat and alfalfa. The lifting of the water plane below from 50 to within 10 of the surface is the result of irrigation and cultivation. It has made the growing of grain a success. Mining, lumbering, and other regional industries have grown rapidly with the development of the new agriculture. A little tabulation of land values and the rapid increase caused by irrigation will prove of interest. The names and figures are taken almost at random from a large number in the possession of the Irrigation Inquiry Office:

Land values in Fresno County.

Name.	Length of years.	Acres owned.	Original cost.	Present value.
W. Mackersie	20	20	$700	$10,000
J. C. Duelle	1	20	4,000	6,000
J. Rowell	15	20	750	6,000
H. Lindstrom	10	10	500	3,000
T. C. White	13	120	6,000	50,000
Richard Williams	13	40	2,025	18,000
E. R. Cabot	7	20	1,000	5,000
R. M. Wilson	8	20	1,300	9,000
Holmes Hakes	6	20	3,500	8,000
Thomas Cross	9	20	1,400	7,000
Hartley Bros	2	40	9,000	16,000
A. E. D. Scott	1½	40	5,000	8,000
M. J. White	8	20	1,200	8,000
Ellen Jacobsen	2	20	1,000	5,000
John Connor	10	20	700	10,000
F. Douglas	12	20	750	10,000
Walter Witney	11	20	700	10,000

THE YEAR'S PROGRESS IN IRRIGATION.

Besides the activity already seen to exist in the artesian wells and underflow areas, the investigations made by the Irrigation Inquiry Office show a rapid increase of interest in the whole subject of irrigation and of the cultivation of the soil thereby, whether the needed supply may be obtained from the surface or subterranean sources. The total area "under ditch" was shown at the close of 1889 to be 13,661,000 acres. That actually cultivated thereby was stated at 7,578,000. The increase in the cultivated area is believed to have been during the past year not less than 500,000 acres, while the area to be served by works now in process of construction will at an early day increase the area served by at least 3,000,000, and possibly 5,000,000 acres. Outside of the artesian wells investigation region a great many discoveries have been made of artesian and underflow water within areas of considerable extent and agricultural importance. In Utah there were reported at the beginning of 1890 not less than 1,794 small flowing wells. According to the officials of the Mormon Church these wells irrigated 1,993 acres. According to the reports made to the Senate committee the area of irrigation was not less than 5,000 acres. Some considerable increase of this area has occurred during the past year. As already stated, Colorado has greatly developed its underflow and artesian area. A remarkable struggle is now going on there between the working farmers and the large ditch corporations. The farmer organizations are a unit in demanding the public control of all irrigation waterways and works. This agitation will probably culminate during the ensuing winter in a vigorous discussion within the State legislature, owing to the fact that a code of irrigation laws has been prepared and will be reported by the State commission. The drift of public opinion in Colorado on the part of water users seems to be toward the establishment of irrigation districts similar to those of the system now under way in California, which, it is claimed, has solved all serious difficulties arising over water title and prior appropriation disputes.

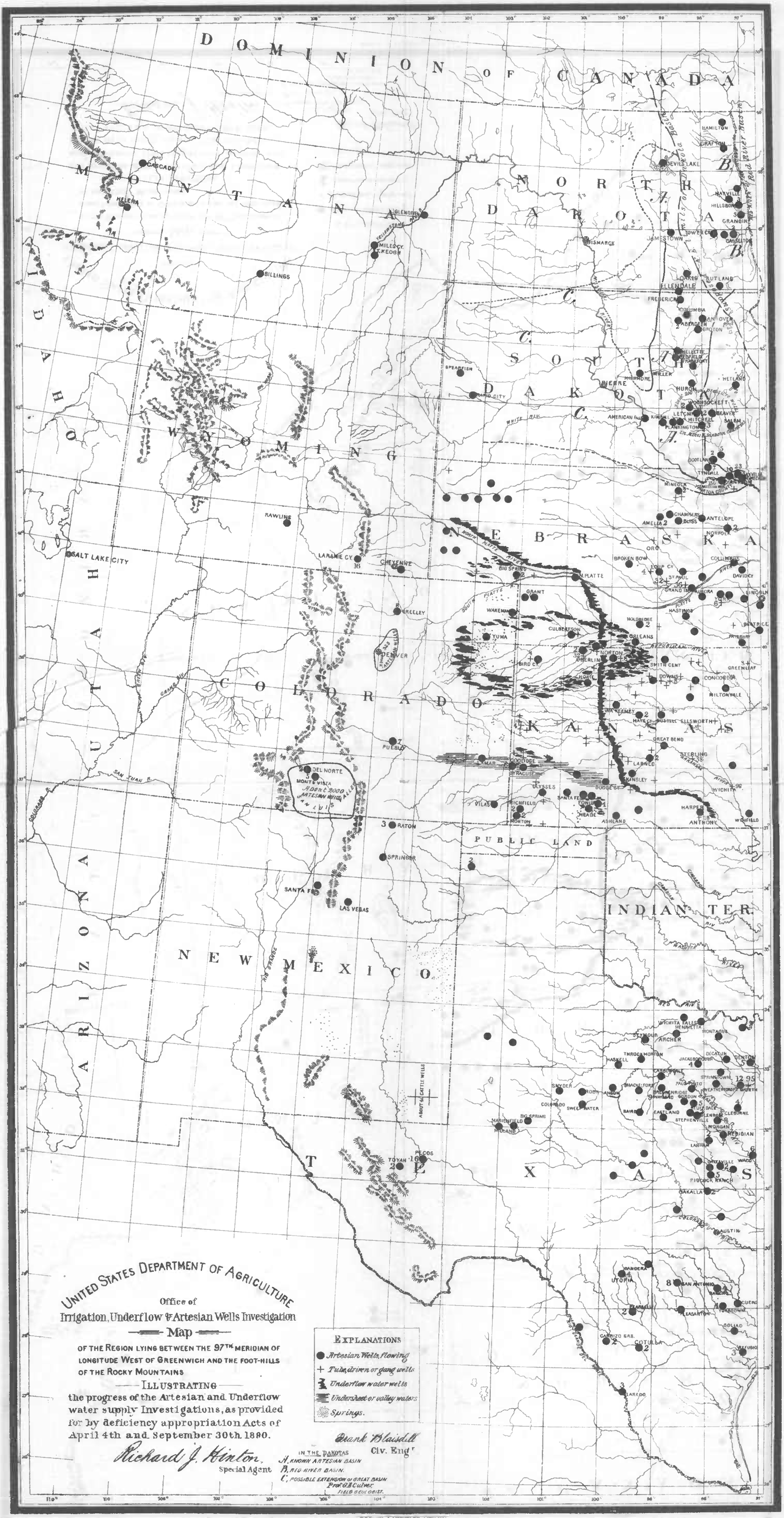
In the north and southwest the area of projected irrigation works has considerably increased, and large systems of reservoirs and canals are being promoted largely by the capital of mortgage land companies in the center and by railroad land-grant owners in the northwest. In California irrigation enormously increases the prosperity of that State. More and more the utilization of the subterranean waters becomes a matter of larger public and individual interest. Sixty thousand acres are irrigated by wells, artesian and bored, driven and gang, 3,000 of which are reported as in operation within California, one tenth of these being used for irrigation. The coming session of the Nevada legislature will be of importance, owing to the fact that reclamation projects under consideration there, are to be debated and decided upon.

In conclusion it may safely be asserted, considering the limitations of time, means, and other conditions, that no more practical investigation has been carried on at less outlay or with promise of larger results to the nation at large and the communities affected than that upon which I have now the honor, in accordance with your directions, to submit a first report.

Respectfully submitted.

RICHARD J. HINTON,
Special Agent in Charge.

Hon. J. M. RUSK,
Secretary.



BEATTY & VOTTELER, LITH. N.Y.

REPORT OF THE DIRECTOR OF THE OFFICE OF EXPERIMENT STATIONS.

SIR: I have the honor to present herewith the report of the Office of Experiment Stations for the year 1890. Although the limits of this report permit only an outline of the operations of this Office and of the stations, I trust the statements here made will suffice to show the value of the work now being done by the stations and the promise of its increasing usefulness. This Office was established in October, 1888, and has therefore been in operation but a little more than two years. Necessarily much of this period has been occupied in learning the needs of the stations, and in devising ways and means for carrying on the work for which the Office was organized. As the stations develop and the scope of their work is enlarged the Office is constantly confronted with new problems. Some of these, together with the need of increased means for discharging the duties imposed on the Office by Congress, are set forth in this report.

Respectfully,

W. O. ATWATER,
Director.

Hon. J. M. RUSK,
Secretary.

INTRODUCTION.

The report of the Office of Experiment Stations for 1890 is for convenience arranged in three general sections, relating to (1) the operations of the Office; (2) the work of the agricultural experiment stations, and (3) the agricultural colleges with which the stations are intimately connected, and the Association of American Agricultural Colleges and Experiment Stations, which is an efficient instrumentality in promoting the interests of both the colleges and the stations.

The work of the Office, described in the first division of this report, has included a very large and varied correspondence; visiting stations; attendance on farmers' meetings and conventions of college and station officers; the collection, cataloguing, and indexing of station and other literature; the collection of statistics and historical and other data regarding the stations and colleges; the indication of lines of inquiry for the stations; and the promotion of co-operation among the stations. Besides these things a very large share of the time and energy of the Office has been devoted to the preparation and publication of a record of the current publications of the stations and this Department, with a full index; the proceedings of the convention of the Association of American Agricultural Colleges and Ex-

periment Stations; bulletins for farmers and botanists; organization lists of the colleges and stations; and circulars and letters of inquiry on topics relating to station work. The preparation of plans for exhibits of station work at the Chicago Exposition has also engaged the attention of the Office. This part of the report also contains an outline of the proposed work of the Office in 1891, a statement of its needs, and suggestions regarding special lines of inquiry which may be profitably undertaken or carried on more extensively by the stations in the immediate future.

The second division of the report, which relates to the operations of the stations, comprises some general statistics illustrating the extent of the station work; facts regarding the stations recently established; illustrations of the practical outcome of station investigations in a number of the States, as reported in 1890; and some conclusions respecting the status, needs, and prospects of the station enterprise. Statistics regarding the names and locations of the stations, the number of station officers of different classes, the lines of station work, the finances of the stations, etc., are given in tables.

In the third division of the report are presented statements with reference to the relations of the stations and colleges, the recent legislation by Congress for the benefit of the colleges, facts regarding colleges recently organized, and an account of the convention of the Association of American Agricultural Colleges and Experiment Stations at Champaign, Illinois. There is also a list of the schools and colleges in the United States having courses of agriculture, with locations and names of chief officers.

Those who desire to investigate the work of the stations in special lines will note that the bulletins and annual reports of the stations are sent, as far as practicable, on application to the respective stations. Communications regarding the work of the stations in any particular line may also be addressed to this Office, where they will either be answered directly or be referred to the proper station. Numerous references to the station publications will be found in this report, either in the text or in foot-notes, and a list of the stations, with the names of directors and addresses, is given on pages 548, 549. The publications of this Office intended for general distribution are sent to those who apply for them. A list and description of these publications may be found on page 548. As the editions are limited, the Office can not undertake to supply full sets of its publications, except in special cases.

OPERATIONS OF THE OFFICE OF EXPERIMENT STATIONS.

WORK OF THE YEAR.

Correspondence.—The correspondence of the Office is large and rapidly growing. The number of letters received and written during the year ending November, 1890, is, in round numbers, 10,000. The rapidity with which this portion of the work of the Office has increased is shown by the fact that the number of letters reported as written and received in 1889 was but 4,800. This correspondence, which reaches all parts of the world, includes requests for publications and for information which may be given by sending publications; inquiries regarding the organization and work of the ex-

periment stations in this and other countries; inquiries for general and special information on a wide range of topics in scientific and practical agriculture; and communications with the experiment stations or their officers regarding the scientific, administrative, and general interests of the stations. Much of the correspondence involves considerable study and labor in the preparation of answers, as well as consultations with State or station officers. It is to be expected that this part of the correspondence will grow in magnitude as the usefulness of the stations becomes greater and their work better known throughout the country and the world. It is believed that the Office, possessing as it does published and manuscript reports of the work of all the stations, will be able to do more and more useful work as a bureau of information.

The visiting of stations, conventions, and farmers' meetings.—Since the last annual report was presented representatives of the Office have visited sixteen stations, have attended the meetings of the Association of American Agricultural Colleges and Experiment Stations at Champaign, Illinois, and the Association of Official Agricultural Chemists, Washington, District of Columbia, and have addressed meetings of farmers in various parts of the country. In order that the Office may be brought into such intimate relations with the stations as are obviously desirable it is important that its work in this direction should be materially increased.

Collection and cataloguing of publications and a mailing list.—The current publications of the stations have been received by this Office with greater regularity the past year than hitherto. Important additions of the earlier and rarer publications of the stations have also been made to the library of the Office. The card catalogue of station literature referred to in previous reports is constantly kept up to date; numerous additions to and corrections in the mailing list of the Office have been made.

Publications of the Office of Experiment Stations.—The principal work of the Office thus far has been that involved in the collecting and preparing of material for publication. The publications issued or in course of preparation are divided into six classes:

(1) The Experiment Station Record, issued in parts and containing brief abstracts of the current publications of the stations together with matters of kindred interest.

(2) Experiment Station Bulletins, intended for station workers and others specially interested in agricultural science.

(3) Farmers' Bulletins, containing accounts of experiment station work and cognate information, in brief, popular form. These are intended for general distribution to farmers and others.

(4) Miscellaneous Bulletins, treating of a variety of subjects more or less intimately related to the stations and agricultural colleges.

(5) Monographs on special topics in agricultural science.

(6) Circulars, containing matters of transient or restricted importance, and usually intended for limited circulation.

A list of the publications for general distribution thus far issued by the Office, with their titles, may be found on page 546. The following seem to require special notice:

Farmers' Bulletin No. 2.—Illustrations of the work of the stations.—This contains brief articles on Better Cows for the Dairy; Fibrin in Milk; Bacteria in Milk, Cream, and Butter; Silos and Silage; Alfalfa; and Field Experiments with Fertilizers. An edition of 150,000 copies was printed and has been distributed, partly through members of Congress. Although no special attempt has been made to advertise this bulletin, it has been in great popular demand and has been very

widely quoted. Experiment stations have requested it for distribution to citizens of their respective States. At the time of this writing there have been received requests from twenty-five stations, aggregating 201,775 copies. The publication of the results of experiment station work in this country for the especial benefit of experiment station workers is provided for in other publications of this Office, but the selection and wide publication of such portions of the station work as are of immediate and practical use to the farmers has been considered from the outset as an important part of the work of this Office. It is to be regretted that lack of funds for printing has made it impracticable to issue these publications as frequently and in as large numbers as the demand for them would warrant.

The Experiment Station Record.—This is intended to be a current record of the work of the stations and of this Department. It contains abstracts of their publications of sufficient length to show the object and plan of the investigations reported, the main facts necessary to an understanding of the way in which the research was carried on, and concise statements of the results. Statistics and other information regarding experiment stations in different parts of the world, suggestions of lines and methods of inquiry for our stations, brief reports of important meetings of station workers, and notes on other matters deemed of general interest to the stations are given in editorial notes. Facts regarding the operations of the stations, changes in their working corps, additions to their equipment, new legislation affecting their work, etc., are concisely stated in experiment station notes. Abstracts of the publications of the Canadian stations have also been included in the present volume, and it is purposed to begin at once to make such brief mention of the work of the experiment stations and kindred institutions in Europe as the limited means at the disposal of the Office for editorial work will allow. A full index of authors and subjects is to be published for each volume.

The difficulty in determining what should be the character and size of this publication, and the interference caused by other work of the Office and inevitable delays in passage through the press, prevented the publication of the earlier numbers of the Record at regular intervals. The first volume consisted of six numbers and contained abstracts of the station bulletins for the calendar year 1889. This volume was finished in July, 1890, at which time the abstracts prepared by the Office were six months behind the station publications.

During the past year the number of station publications has considerably increased, both because new stations have been established and because the other stations issue bulletins more frequently. Moreover these publications are now of greater average length, and contain more scientific material. This is due to the fact that the stations are becoming better established and more of their experiments are reaching completion. The editorial labors of the Office have in consequence been materially enlarged. In view of the number of station publications and the desirability of furnishing summaries of current experiments to the station workers and the public as promptly as possible, the Record is to be issued for the present fiscal year in monthly instead of bimonthly parts. Since the first of July the Office has made a special effort to bring the abstracting of the station publications as nearly up to date as practicable, and has so far succeeded that under present arrangements these publications

are, with rare exceptions, abstracted within a few days of their receipt in the Office. Six numbers of the second volume of the Record, containing abstracts of 160 publications, have been prepared for publication during the past five months. At least a month, and sometimes more, is required to get a number of the Record through the press. Moreover, the abstracts of many station publications are delayed by causes over which this Office has no control. It has not yet been possible to secure the prompt and orderly receipt of all publications. Some come to us long after their issue; others come out of regular order. Station bulletins and reports often bear upon their pages a publication date very much earlier than the actual one. Errors or obscurities of statement in the original publications often involve correspondence, which consumes considerable time and labor. Inasmuch as the Record is and should be an authoritative exposition of the current work of the stations and the Department, great pains should be taken to have it accurate not only in a general way but in every detail. To secure this involves a very large amount of the most painstaking labor both in the preparation of the abstracts and in the reading of the proofs. Errors have undoubtedly crept in already, and we can not hope to keep entirely free from them in the future. But it is the intention of the Office to perform this part of its task with a due regard to the magnitude and importance of the enterprise which it represents.

Owing to the fact that the appropriation for this Office has not been increased during the present fiscal year the digest of experiment station reports, bulletins on swine feeding and the monographs on the nutrition and feeding of domestic animals, the preparation of which was announced in the last Annual Report, have not progressed as rapidly as was expected. It is hoped, however, that means will be speedily provided for their publication.

SPECIAL FEATURES OF THE WORK OF THE COMING YEAR.

Indexes of experiment station publications and kindred literature.—The mass of literature containing reports of investigations on agricultural science in this country and Europe has grown to be so large that it is very important that general indexes should be prepared and kept up to date. It is very appropriate that an office like this, having a permanent organization, should undertake this work, which would be too expensive for private enterprise, and which when once begun, should be conducted on a consistent plan from year to year without interruption. The necessity for such an index has been appreciated by the Office from the outset of its work. There are, however, many difficulties in the way of its realization. Questions as to the proper system for the classification of topics, and the amount and kind of material to be included in such an index have required a large amount of preliminary study. The collection and cataloguing of the publications to be indexed have so far occupied a good deal of the attention of the Office.

Progress has, however, been made during the year in the formulating of definite plans for a general index of station literature. These plans were presented at the recent convention of the Association of American Agricultural Colleges and Experiment Stations at Champaign, Illinois, where they elicited much interest and the Office was earnestly urged to prosecute the work. It is hoped, therefore, that some portion of such an index will be published during the

coming year. The plan of work proposed is in general terms as follows: The system of classification and the amount of matter to be contained in the index will be finally decided upon after conference with station workers and others interested, and the Office will prepare a card index by subjects of the current publications of the American stations. Portions of this will be printed from time to time for distribution. Whenever the means at the disposal of the Office are sufficiently enlarged the indexing of the past publications of our stations, as well as the publications of the kindred institutions elsewhere, will be taken up. In this connection it is worth noting that the index of Vol. I of the Experiment Station Record, which is at the same time an index of the station bulletins of the year 1889, fills 30 pages, closely printed, in small type and in double columns.

Compilation of results of European research.—In the previous reports of this Office reference has been made to the pressing needs of our experiment stations that the fruits of European research should be made available to them. Despite the limited facilities of this Office the need of this work is so urgent that a beginning has been made. In connection with the monograph on swine feeding the results of European experimenting on that subject are being collated. A similar attempt is being made to collate the results of later inquiries regarding the effects of fodder upon milk production by cows. A number of the more important European journals and other publications have been selected, and brief abstracts of inquiries reported in them are in course of preparation for the Experiment Station Record.

THE INDICATION OF LINES OF INQUIRY TO BE PURSUED BY THE STATIONS.

Specific suggestions and directions for field experiments with fertilizers were made after a conference with representatives of stations, and published in Circular No. 7 of the Office, as elsewhere stated. Plans for co-operative experiments on the effects of fodder upon milk production by cows are being prepared in accordance with a conference with a committee appointed for the purpose at the recent convention of the Association of American Agricultural Colleges and Experiment Stations in response to suggestions by the Director of this Office.

Investigations of feeding stuffs.—The need of improvement in the methods of analysis of feeding stuffs and foods, and for estimating their nutritive values has been repeatedly insisted upon by this Office. At the instance of the Director it has been made an especial theme for consideration by the Association of Official Agricultural Chemists. The report of the committee upon the subject presented at the meeting of the association in Washington, August 28–30, 1890, will be published in full in the forthcoming report of the proceedings of the association by the Division of Chemistry of this Department. In the Experiment Station Record, Vol. II, No. 5, the need of investigations on this subject is insisted upon, and plans, ways, and means for them are discussed.

It is safe to say that all of the work we have done in the past and are doing to-day in the analysis of feeding stuffs and the feeding trials based upon them will have to be revised and much of it dis-

carded. In other words, a large amount of work is being done which is not bringing the needed results, can not in the nature of the case be of the highest and most enduring value, and much of which may have to be done over again when correct methods shall have been devised.

The first step toward reform must be research in analytical, organic, physical, and physiological chemistry. The needed improvements of our methods will evidently come only as fast as does the chemical and physiological knowledge which must serve as a basis for changes. This means that the most abstract and profound study is necessary. Fortunately such study is more and more engaging the attention of chemists and vegetable physiologists.

Investigations in these lines have been already undertaken by the Division of Chemistry of the United States Department of Agriculture, by several of the experiment stations, and by other institutions of research. The work of the Association of Official Agricultural Chemists in developing and improving the methods of analysis has been of the greatest value. For the collating of the results of previous inquiries, and for the prosecution of the necessary investigations, co-operation of large numbers of specialists will, of course, be requisite. We may confidently expect that experiment stations will be able to devote more and more labor to these higher inquiries. The increased resources of our agricultural colleges will enable them to encourage such researches. The scientific value of this work is such that chemists in other colleges and universities ought to be led to join in it. And is it too much to suggest that international co-operation might be secured? The expense of this research may be best met by the wise expenditure of relatively small sums of money judiciously distributed, so as to stimulate investigations and bring them to completion. In what the Smithsonian Institution has done in times past in promoting research by small amounts of money, we have an illustration of what might be accomplished here. The result would be useful in several ways. It would encourage research, develop talent, and improve the intellectual tone of the institutions where such work was being done. Its influence upon the development of science in this country would be excellent and the practical value of the outcome would many times exceed the cost.

Investigation of soils.—In the report of this Office for 1889 attention was called to the importance of more thorough investigation of the soils of the different parts of the country for the purpose of securing more extended knowledge and better development of their agricultural capabilities. Such investigations form a part of the duty of the stations, as defined by act of Congress. The subject was discussed by the Association of American Agricultural Colleges and Experiment Stations in its convention at Washington in November, 1889, and a resolution was passed requesting the aid of the Department in collating and publishing the results of soil investigation at home and abroad. A number of the stations are already prosecuting investigations in this line. The present purpose of illustrating the importance of these inquiries and indicating what is needful for their best success will be served by specific illustrations. Two are therefore selected, one from South Carolina and one from California, thus exemplifying the advantage of such inquiries in the older regions of the East and the newer ones of the West. In the one case the improvement of soils more or less exhausted by culture is particularly indicated; in the other the advantage of pioneer inves-

tigation in behalf of the settlers of new territory is most plainly shown.

Soil investigations by the South Carolina Station.—The South Carolina Station has undertaken a systematic study of the soils of its experimental farms in Spartanburgh, Columbia, and Darlington and of other typical soils of the State. These inquiries include observations on the meteorology, topography, and geology of the regions where the soils are located; the natural growth upon the soils, especially of the trees; and the methods of tillage and manuring practiced and the crops produced. With these have been made field experiments on the effects of different fertilizers on the growth of cotton, corn, wheat, and other crops on the different soils; mechanical and chemical analyses of the soils and special studies of their physical properties as related to plant growth and crop production. Taken in connection with the other work of the station on varieties of crops best adapted to the different regions and conditions and their proper utilization, the plan begun would, if logically carried out, embrace such meteorological, topographical, physical, chemical, botanical, and agricultural studies as would lead to a thorough understanding of the climate and soils of the State, the crops best adapted to different regions, and the proper methods of tillage and manuring. It would in fact constitute an agricultural survey of South Carolina.

In a report to the director of the station Professor Whitney thus tersely states some of the reasons for prosecuting these inquiries:

The various parts of this State are naturally arranged according to certain marked and well-defined classes of soil and climatic conditions. Certain products are peculiar to certain sections and are excluded from others, or their cultivation or character must be materially modified. This is notably the case with cotton and rice. We have within the State regions where the conditions favor their most productive growth and others where they can not be grown. The causes favoring the production of sea island cotton on the coast and its failure to mature on the uplands is in itself a subject worthy our most careful study and investigation. The reason will be found in the physical conditions of the soil, methods of cultivation, and climatic conditions. As the maturity of cotton has been materially hastened on the sea islands through methods of cultivation, that is, by changing the physical conditions under which it grows, there seems every reason to believe a systematic study of these soils and conditions of growth would have immediate practical benefit to our farmers and the advancement of agricultural science. Further than this, the small yield of our grain crop at the South, the lateness of our bottom-lands, the rusting and other diseases of cotton, the washing of our red lands in the up country all depend to a large extent upon the physical character of the soil, as well as in a lesser degree upon meteorological conditions, and certainly if these matters were better understood we would speak more intelligently of remedies to be applied. Further than this and intimately connected with the subject in hand, is the physical action of manures and fertilizers, which has never been understood, but which we have worked out in part within the past year.

Corn, wheat, oats, and such staple crops of the North and Europe will grow almost anywhere from the intensely hot countries to frozen Siberia, and the experimenters at the North and in Europe have been almost unable to obtain conditions unfavorable for these crops. The soils at the North are also more mixed than they are with us, owing to the changes of the glacial period, so they have not the typical soils that we have, and the limited areas of uniform soil are materially modified by generations of manuring and intensive cultivation. Cotton and rice are more sensitive to their surroundings, and consequently are better adapted to the study of the soils than the staple crops just mentioned.

It is only by comparison of conditions existing in different characteristic soils that the relation of these physical properties of soil to plant growth and crop production will be made apparent.

Mechanical and chemical analyses of soils of the three experimental farms of the station and of sea island cotton and rice land

soils of the coast of South Carolina have been made by Prof. R. H. Loughridge.

Investigations on the physical properties of soils, as related to plant growth and crop production, have been conducted by Prof. Milton Whitney. These included laboratory experiments on the soils of the station farms, sea island upland cotton soils, and upland cotton soils of different geological formations, supplemented by observations in the field and by meteorological studies. The scope of the work may be inferred from the following summary:

Soil particles.—(1) Interpretation of the result of mechanical analysis. (*a*) Number of particles in unit weight or volume of soil; (*b*) diameter of average-sized particle of soil and the mean arrangement of the particles; (*c*) surface area of particles (this shows the need of still further perfecting the method of mechanical analysis). (2) On a movement of soil particles due to changing water content and changing temperature, as related to the growth of roots, and the physical action of manure, with the effect of barometric changes and vapor pressure on the same.

Soil moisture.—(3) Method for the determination of the moisture in the soil by electrical resistance. (4) On the movement of soil moisture. (*a*) The cause and laws of the movement; (*b*) the effect of temperature; (*c*) the effect of manure; (*d*) the effect of rain; (*e*) the effect of cropping and cultivation. (5) Calculation of the relative movement of soil moisture in different soils from the mechanical analysis. (6) Calculation of the relative rate of evaporation and underdrainage from different soils from the mechanical analysis. (7) On the capillary value of different soils from the mechanical analysis. (8) Effect of fineness and compactness on the water-holding power. (9) On the action of underdrains in the soil and of how they act. (10) On the flocculation and subsidence of clay particles. (11) On the swelling of clay when wet. (12) On the compacting of soils by rain. (13) On the physical action of manures and fertilizers.

Soil temperature.—(14) New form of soil thermometer, which registers the maximum and minimum temperature of a definite layer of soil. (15) The relation of the soil to heat as observed in the field in typical soils or under different conditions of cultivation and fertilization. (16) Calculations of the relation of different soils to heat from the mechanical analyses, with the effect of the water content, cultivation, and cropping. (17) The actual temperature of different soils, with range, etc. (18) Study of the loss of heat from different soils. (*a*) As calculated from the mechanical analysis; (*b*) as determined with the radiation thermometer. (19) Specific heat of typical soils.

Meteorology.—(20) Temperature of the air and soils, and amount of moisture in same most favorable for plant growth. (*a*) Distribution throughout the growing season; (*b*) the relative effect on the growth of plants and crop production; (*c*) how modified by manure and cultivation. (21) The estimation of the actual amount of moisture in the soils from time to time. (22) Influence of meteorological conditions. (*a*) On grain production, as explaining low average yield of grain at the South; (*b*) on the distribution of crops throughout the State; (*c*) on the growth and ripening of crops. (23) Amount and intensity of sunshine available for the crop. (24) Effect of wind movement on plant growth, especially as to the amount of ammonia supplied to crops.

The practical applications of the principles involved in researches of the character indicated are interesting. The culture of cotton gives manifold illustrations. The cotton plant requires in the earlier period of growth plenty of warmth and moisture to develop "weed" (stem and foliage), while in the later period of growth less moisture is desirable so far as to favor full and early development of seed including the lint. The meteorological conditions of South Carolina are favorable for this, but right cultivation of the soil is necessary. In other words, success in cotton growing depends upon keeping the soil in the right physical condition. The improvement of late years in the regulation of the moisture by the management of the soil in cotton culture are noteworthy.

The sea island cotton is now famous for its quality and brings a high price. Yet some years ago it was thought the culture of sea island cotton would have to be abandoned even on the sea islands, and, indeed, the ordinary upland cotton was substituted to a large extent for the long staple because it was less liable to injury from the caterpillar, and because the season of growth of the long staple was so long as to render it liable to be caught by frost, making the crop very uncertain. The systematic use of Paris green and London purple, under the very watchful and intelligent care of the planters, makes the crop secure from the ravages of insects, and the improved method of culture at present employed materially hastens the maturity of the plant, bringing it well within the length of the season, increasing the yield and improving the quality of the lint.

In brief, here is a case in which threatened failure has been followed by assured and remarkable success, and the agriculture of a region most notably benefited by management which has fitted the physical character of the soil to the needs of the plants.

Professor Whitney thinks that similar improvement is feasible in other parts of the State. He cites specific localities where this may probably be done, and explains the conditions of soil and climate upon which his judgment is based. The improvement may and doubtless would come in the course of years or generations through practical experience, without the aid of scientific inquiry, but here as in many other cases, that inquiry would help to the speedy solution of the problems, bridge over costly experience, and repay its expense many fold.

Soil investigations by Professor Hilgard, Director of the California Station.—Volumes V and VI of the United States Census of 1880 contained detailed reports upon investigations of the soils of Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Louisiana, Texas, Indian Territory, Arkansas, Missouri, Mississippi, Tennessee, Kentucky, and California, by Prof. E. W. Hilgard and associates. In connection with the Northern Transcontinental Survey, Professor Hilgard was for some time engaged in investigations of the soils of the northwestern regions of the United States, the results of which have not yet been published in detail. As a part of the work of the California Station carried out under his direction, over two thousand two hundred samples of representative soils of that State have been collected, and when desirable, subjected to chemical analysis and physical investigation. The data thus used have served as a basis for a classification of the soils of the State. Parallel with these studies of soils, numerous analyses of waters have been made to learn their values for irrigation and other purposes.

In communications to this Office, and more especially in a report of the California Experiment Station,* Professor Hilgard has summarized the results of a large amount of experience in the study of soils, of which his own for thirty-five years forms a prominent part. He urges the value of chemical as well as physical analyses of soils and explains their interpretation; insists upon the especial importance of investigations of the soils of the newer States and Territories, where the question is not how to restore or maintain the fertility of the soil, but rather "Which soils are most likely to afford the settler a comfortable living, and what cultures are best adapted to the prevailing conditions of soil, climate, and market;" cites instances in which individual settlers and colonies have suffered disastrously from mistakes in the selection of place for settlement because they did not understand the nature of the soil, as well as instances in which soil investigations have been of the utmost value in preventing such mistakes and in finding remedies; and argues strongly in behalf of an agricultural survey of the United States. The following statements are from a communication by Professor Hilgard:

A full and accurate knowledge of the agricultural features and other industrial resources of the State is of the most direct and obvious importance to every one concerned in industrial pursuits. It is wanted by the immigrant or the settler seeking a new home suitable to his tastes and resources, as well as by the large farmer and capitalist desiring to locate and invest to the best possible advantage.

Most of the older States have long ago partially satisfied this demand in some form; mostly in connection with the public surveys usually named from their fundamental feature, geological surveys, but commonly charged as well with the full investigation of the other industrial features of the State. It is but fair to state, however, that in but few cases have these surveys gone into the agricultural work whole-hearted. * * * This has occurred largely for the reason that no agricultural experts have been employed who could have made observations sufficiently broad to cover the requirements of agricultural practice and presented them in language intelligible to the farmer. * * * Outside of the cotton States, where such work was to a certain extent carried on in connection with the Tenth Census as well as by a few State surveys, it is now practically impossible for most of those interested to obtain full, authentic, and impartial information concerning any particular region of the United States without the trouble and expense of a personal visit. The demand for this kind of information is shown by the publication of numerous pamphlets and newspaper articles, describing more or less fully and correctly certain regions recommended for immigration or settlement. But the fact that these publications emanate largely from interested parties and are compiled by persons unused to accurate observation of natural phenomena and not possessed of the means for thorough investigation, greatly reduces the usefulness even of the correct information thus conveyed.

Moreover, the possession of an accurate description of the agricultural features and peculiarities of a State is an indispensable prerequisite to the giving of truly practical instruction to the youth of the States in the courses at the agricultural colleges. Nothing can be more obvious than that they should be taught not only what they should have to do in certain hypothetical cases, but also what are the circumstances and difficulties with which, in actual fact and practice, they will have to deal in their own State.

The experiment stations now established in each State are designed and constantly called upon to furnish information and advice regarding the best agricultural practice within their respective spheres of action, and to solve existing difficulties and questions by experimentation. But as a matter of fact they do not possess and have not the means or even definite prospects of getting possession of the actual facts of the cases with which they will have to deal. They are placed in the position of a physician who is expected to prescribe for a patient of whose condition and ailments he knows nothing except what public rumor or the statements of some person ignorant of medical science may have led him to conjecture.

In order that these institutions may properly fulfill the functions imposed upon them, they should not be obliged to await the tardy and irregular action of appli-

* Reports of the Agricultural Experiment Station of the University of California for 1888 and 1889.

cants for information or to rest content with the fragmentary and unreliable observations that may accompany such requests. They themselves should be in possession of the actual facts, as collected and co-ordinated by competent observers and as published on a uniform plan by one central bureau, and thus be able to foresee and investigate the difficulties and problems that will beset the individual settler or farmer in advance of the time when irrational culture may have rendered such solutions more difficult of practical application. In other words, they should have as a basis for effectual work the operations and results of *an agricultural survey of the whole country.*

The information desired by the intending settler or land purchaser will usually include the following points:

What is the character of the climate? The face of the country, wooded or treeless? What is the quantity and quality of the water supply, and how far is it down to bottom water?

Is the land capable of yielding profitable crops without fertilization or other costly improvements; and, if so,

How long is it likely to hold out under ordinary (exhaustive) culture before it will require fertilization?

When it does give out, what fertilizer will it require first, or what other mode of restoring productiveness can be employed?

To what crops is the land, from its (physical and chemical) nature, best adapted?

In the great majority of cases these questions, so vitally important to the welfare of the settler, can be quite fully answered by properly qualified observers, while wild guesses are all that the average farmer will be able to make regarding some of the most essential points in the premises. These require a knowledge—from actual observation—of the physical and chemical characters of the soil; and in the study of these the expert must be aided by all the natural characteristics that would guide the judgment of the "old farmer," as well as by the discussion of the experience that may already have been had in cultivation. The mere identification of soils, their mapping so as to show how far the experience acquired at any one point may serve to forecast the value and proper treatment of larger areas, would be sufficient to justify a considerable expenditure in field surveys.

But in the present state of science much more than this can be done, and the agricultural interest is entitled to the very best that can be accomplished.

It has been said * * * that a good farmer could tell all about a soil so soon as he saw it and that such investigations are uncalled for. This is simply and grossly untrue outside of the immediate range of the experience of nine tenths of the farming population; but granting it true of the *good* farmer, then just such persons, but properly qualified to give the reasons for the faith that is in them—in other words, qualified agricultural experts—should be made to do this work for the other nine tenths, who now go ahead blindly, experimenting at random in new climates and soils and each learning by bitter experience what might have been foreseen and prevented. It is difficult to see why what is done by geological surveys for the miner should not be equally, at least, done for the farmer by properly conducted agricultural surveys. The agricultural expert should have all the knowledge possessed by the good "old farmer," but a great deal more in addition by using all the lights that modern science can throw upon the subject.

The reports of the California Station above referred to give numerous examples of forecasts which were made upon the basis of such information and have been verified by actual experience. They have to do with such subjects as irrigation of arid lands; remedies for "alkali," and reclamation of alkali soils; the evil of impervious subsoils and the remedies for it; and the occurrence and lack of lime, potash, and phosphoric acid in soils. Their full import, however, can hardly be realized by those not familiar with the regions and the details. Areas in California as large as Eastern States, once arid and waste have been reclaimed by irrigation and tillage; direful loss has been threatened, but means of prevention have been discovered, largely through the aid of the station. Such, for instance, has been the case in portions of the "Great Valley" of California which is traversed by the Kern, San Joaquin, and Sacramento Rivers. The fundamental facts, broadly stated, are these: The regions referred to were waste, not from lack of plant food, for this was often present in abundance, but from lack of water. Irrigation

and tillage have supplied the water. In numerous cases, however, excess of salts consisting chiefly of sodium chloride, sulphate, and carbonate, and popularly known as alkali, has accumulated at or near the surface of the soil, sometimes before irrigation was introduced and sometimes as the result of it. The effect of this alkali has been to injure or destroy the fruit, grain, or other crops. It is brought to the surface of the soil by water which rises from below and evaporates from the surface. The remedies are tillage to prevent evaporation, drainage to wash the salts out, and amendments, especially gypsum, to counteract their effect.

Results of chemical and physical investigations of soils.—Among the important general conclusions derived by Professor Hilgard from studies of soils in California and other States are the following: The soils of California, studied in nearly all cases, are *calcareous*, *i. e.* contain enough of carbonate of lime to impart to them the distinctive character of such soils, and to render a further addition of that substance as a fertilizer superfluous and ineffective. The great majority contain amounts of *potash* largely in excess of those found in the soils of the region east of the Mississippi, very often exceeding 1 per cent. Potash salts are often found circulating in the soil water; the conclusion being that the use of potash as a fertilizer will likewise be uncalled for for a long time to come. On the other hand, it has been found that *phosphoric acid* exists in the soils of California in relatively small supply as compared with those of the East, and of Oregon, Washington, and Montana.

Actual trial both at the California Station and by farmers has corroborated these conclusions.

These investigations have called attention to the broad fact, heretofore overlooked, that *the accumulation of lime in the soil of arid regions* is as necessary a consequence of the climatic conditions as is that of the alkali salts; and that such countries must under ordinary conditions be expected to have calcareous soils. This generalization is amply verified by numerous soil analyses from the States and Territories west of the one hundredth meridian, made in connection with the Northern Transcontinental Survey, but thus far unpublished.

In the States of Alabama, Mississippi, and part of Louisiana the agricultural survey, while classifying the lands so that the experience had in one part of a soil region would be known to be applicable to the rest, has been specially useful in the discovery and examination of the beds of calcareous and greensand marls, which are admirably adapted to the restoration of the productiveness of the lands exhausted by long cropping with cotton.

In the same States certain soil regions that had been highly extolled by land speculators on the basis of their pleasant appearance were proved to be absolutely incapable of profitable cultivation without improvements too costly to be undertaken until land values shall be considerably higher than is the case at present. The best mode of improvement has been pointed out and in several cases successfully carried out on a small scale.

In California the planting of colonies on lands of good appearance, but which ultimately proved unfit for permanent cultivation, has in several instances been carried out, in others attempted. The existence of official reports on such lands would have prevented large losses of money, and even much suffering.

Interpretation of analytical results for practical purposes.—In form-

ing a judgment regarding the practical import of the data resulting from a soil analysis the simple question must be, "What does the comparison of such data with actual agricultural practice teach us?"

The first broad statement that may be made is that *in no case has any natural virgin soil showing high plant food percentages been found otherwise than highly productive under favorable physical conditions.* This being true, the practical value of soil analysis is thus far established, that it can teach the settler, *a priori*, that certain soils, new to him and to everyone, are a safe investment.

But the reverse is not true, viz, that low plant food percentages necessarily indicate low productiveness.

That it *can not* be true is evident from the simple fact that heavy clay soils rich in plant food may advantageously be diluted with arid sand, several times over, thereby increasing instead of diminishing their productiveness, *because of improved physical conditions.* This fact is abundantly exemplified in the daily experience and practice of gardeners. In nature it is emphasized by the effects of the washing down of the poor, sandy soils of pine and "black-jack" ridges upon the heavy, black prairie soils of the Southwestern States, where the "mahogany" soils so formed are in the highest repute for both productiveness, "safeness," and durability, and are invariably preferred to the black, heavy prairie soils.

A material limiting cause in the premises is the nearness to the surface of either the water-table, or of hardpan difficult or impossible to penetrate by the roots. It has repeatedly occurred in California that sandy soils of low plant-food percentages that yielded heavy crops while the water was at the depth of 10 or 12 feet, ceased to produce so soon as, by increase of irrigation in the neighborhood, the water rose within 5 feet or less of the surface. Examination showed that the active root system has thus been confined to less than half of the bulk of soil previously occupied by it in these pervious soils. In clay soils 5 feet would have been more than sufficient depth for the same crops, as their roots would not go deeper in any case. In the same region, calcareous hardpan lying at the same depth has, like the water, caused production to languish after a few years, but when it was broken through, after the lapse of a year, vigor was restored.

It is then absolutely indispensable that both the physical character—as to penetrability, absorptive power, etc.—*of a soil should be known as well as its depths above bed-rock, hardpan, or water, before a judgment of its quality, productiveness, and durability can be formed from its chemical composition.* But it is equally obvious that *without* a knowledge of the chemical composition, it is not possible to form such a judgment with "*connaissance de cause.*" Definite information on *both* classes of properties must be before the agricultural expert; and it will be his own fault if from such data he can not beat the old farmer in judging of soils. * * * A *properly qualified* agricultural chemist can render the most direct and important services to the farmer, settler, and immigrant, by forecasting both the best adaptation of the lands occupied, the mode of culture, and the improvements and fertilizers that will be first needed when (as now invariably happens) the soil "gives out" under exhaustive culture. This, and not mere glittering generalities, is what an agricultural survey deserving of the name should supply. In most of the country lying between the Alleghanies and the Pacific Ocean, the history of each field is generally still in the memory of persons living; and thus the most valuable direct evidence of the effects of cultivation on natural soils, and of the extent to which soil examination can be useful to practice, is within the easy reach of our experiment stations. It will be their most grevious fault if these advantages, scarcely to be found in any other country in the world, are not utilized by them for the advancement of the science as well as the practice of agriculture.

To the foregoing illustrations of what the stations are doing in this line others of very considerable interest and value might be added. The purpose here, however, is to urge that what is being done be done right and in such a way as to bring the best results from the work as it goes on, and to lead to the most effective organization and carrying out of investigations in the future.

This idea was urged in Circular No. 7 of this Office, in which it was said that "we must understand the topography, geology, and the meteorology of the different regions, the boundaries of the faunal

and floral areas, and the chemistry and physics of the soils themselves before we can know what we need to know about the agricultural capabilities of the wonderfully diverse soils of the country and the most advantageous ways to cultivate them."

It is fortunate for the prosecution of these inquiries that the agencies are already in operation and all that is required is their natural growth and extension. In fulfillment of the duties imposed upon them by Congress, the stations are instituting the investigations in the different parts of the country where they can best observe the characters of our soils and the demands of agriculture. The topographical and geological inquiries needed as part of the foundation of their work are or can be provided for in connection with organizations already established. What is now wanted is to collate the known facts and devise wise and economical methods of inquiry and push that inquiry as the wants of localities demand and science and experience advise. The collating of the fruits of experience, both American and foreign, the elaboration of methods, and the arranging of co-operative investigation can be most economically and effectively done through the Office of Experiment Stations in connection with the stations, colleges, and other institutions of research. As the methods are worked out they can be used by the stations in their several localities as circumstances demand and opportunities permit, and thus the enterprise will have its normal growth and the work be most advantageously done.

REPRESENTATION OF THE EXPERIMENT STATIONS AT THE WORLD'S COLUMBIAN EXPOSITION IN 1893.

In consideration of the importance of an exhibit by the experiment stations at the coming Exposition in Chicago, plans were drawn up by this Office and presented at the convention of the Association of American Agricultural Colleges and Experiment Stations at Champaign, Illinois, in November, 1890, by Mr. A. W. Harris, assistant director of this Office. They were very cordially received, and a committee was appointed to represent the association in conferring with this Department and making arrangements for such an exhibit. The committee are Director Armsby of Pennsylvania, Professor Morrow of Illinois, Directors Thorne of Ohio, Tracy of Mississippi, and Henry of Wisconsin.

The plan includes (1) an experiment station in operation, to be manned by station workers, containing an office, library, chemical, botanical, and entomological laboratories, greenhouse, stable, and dairy. (2) An exhibit of the work of the stations, to be made up of two parts, the first containing exhibits of the individual stations, showing location, climatic relations, plans of buildings, history, resources, principal lines of work, etc.; and the second consisting of topical exhibits of the work of the stations, illustrating methods, apparatus, and results pertaining to special subjects or classes of subjects.

Small pamphlets, primers, or leaflets explaining the exhibit are contemplated, and it is proposed that members of station staffs, students of the agricultural colleges, or others be detailed as demonstrators to explain to visitors the meaning of the exhibit.

STATISTICS OF THE STATIONS.

Agricultural experiment stations are now in operation under the act of Congress approved March 2, 1887, in all the States and Territories except Montana, Washington, Idaho, Wyoming, and Oklahoma. In several States the United States grant is divided so that forty-six stations in forty-three States and Territories are receiving money from the United States Treasury. In each of the States of Connecticut, Massachusetts, New Jersey, and New York a separate station is maintained entirely or in part by State funds, and in Louisiana a station for sugar experiments is maintained mainly by funds contributed by sugar planters. In several States branch or substations have been established. If these be excluded the number of stations in the United States is fifty-two. During the past year six new stations have been established, viz, in Northern and Southeastern Alabama, Arizona, New Mexico, North Dakota, and Utah. The stations with this Office received during 1890 $988,146, of which $652,500 was appropriated from the National Treasury, the rest coming from State governments, private individuals, fees for analyses of fertilizers, sales of farm products, and other sources. The stations employ four hundred and twenty-nine persons in the work of administration and inquiry. The number of officers engaged in the different lines of work is as follows: directors 66, chemists 101, agriculturists 63, horticulturists 47, botanists 42, entomologists 33, veterinarians 19, meteorologists 11, biologists 4, viticulturists 2, physicists 3, geologists 1, mycologists 2, microscopists 4, irrigation engineer 1, in charge of substations 16, secretaries and treasurers 21, librarians 5, clerks 18. There are also forty-two persons classified under the head of miscellaneous, including superintendents of gardens, grounds, and buildings, foremen of farms and gardens, apiarists, herdsmen, etc.

During 1890 the stations have published 36 annual reports and 225 bulletins. The mailing list of the stations now aggregates about 340,000 names. At a low estimate a total of 35 millions of pages, containing information on agricultural topics, have been disseminated among the people during the past year; furthermore the results and processes of experiments are described in thousands of newspapers and other periodicals. The mailing lists of the stations have largely increased during the year. The calls upon station officers to make public addresses are numerous and increasing. The number of such addresses reported to this Office as delivered during the past years is about 750. The station correspondence with farmers is now very large and touches nearly every topic connected with farm theory and practice. A number of stations have made exhibits of the processes or results of their investigations at the State and county fairs. There have been many evidences of public approval of the stations and their work as indicated by acts of the State legislatures in their behalf and gifts of money by local communities, agricultural associations, and private individuals, and by commendations of their work in the agricultural journals as well as by farmers. The relatively large space given to reports of work of the stations in the agricultural press is also an indication of the increasing favor in which the work of the stations is held.

By an act of the legislature passed in December, 1889, to take effect November 1, 1890, the connection of the South Carolina Experiment Station with the University of South Carolina has been severed and

the station has been removed from Columbia to Pendleton, where it is now in operation as a department of the newly established Clemson Agricultural College.

The post-office address of the Georgia Station has been changed from Griffin to Experiment, and that of the Maryland Station from Agricultural College to College Park.

STATIONS RECENTLY ORGANIZED.

The North and Southeast Alabama Branch Agricultural Experiment Stations were established by an act of the State legislature approved February 28, 1889, and are connected with agricultural schools organized under the same act. They are under the management of boards of control, consisting of the State commissioner of agriculture, the director of the experiment station of the Agricultural and Mechanical College of Alabama, and of five farmers residing in the vicinity of the respective stations, appointed by the governor of the State. The North Alabama Station is located at Athens, and its director is C. L. Newman, B. S. The Southeast Alabama Station is located at Abbeville, and its director is T. M. Watlington, B. S.

In accordance with a resolution of the board of regents of the University of Arizona, adopted July 1, 1889, the college of agriculture and an experiment station have been organized in connection with the university. Selim M. Franklin, Ph. B., was at that time elected professor of agriculture and director of the station, but he has since been succeeded in both offices by F. A. Gulley, M. S., formerly director of the Texas Station. The station is located at Tucson, Arizona. The other members of the station staff are C. B. Collingwood, B. S., chemist, and Ferdinand Brandt, horticulturist. M. P. Freeman, president of the university, is *ex officio* president of the governing board of the station.

A substation for Southern California was established in July, 1890, at Pomona, Los Angeles County, in conformity with the result of explorations made last season with the view of finding a locality reasonably representative of a region which includes both the coast from Santa Barbara to San Diego and the more or less arid lands of the interior. On the ground that the station should be situated within the great valley of that portion of the State (which reaches from Los Angeles to San Bernardino Mountain, and which is the largest and earliest settled tract of agricultural land south of the San Joaquin Valley), a compromise location within that valley seemed to be best realized on or near the water divide between the two river systems that now drain it diagonally, viz, the San Gabriel and Santa Ana Rivers. As in former cases, the land for the station has been donated. The soil of the main tract of 30 acres is the reddish loam, which is considered especially favorable to the success of citrus fruits. The 10-acre tract is a fair sample of the black loam that constitutes most lands of this as well as of the coast region, is especially adapted to field crops of all kinds, and needs no irrigation. The two tracts lie about 2 miles apart. On the larger one the station buildings will be erected with the aid of about $3,000 subscribed by the citizens of Pomona. At a late meeting of the regents of the University of California, Mr. Richard Gird, who gave the land for the station, was appointed "patron" of the South California Station. Buildings are being erected and it is hoped that the station

will be fully stocked for the coming season's work. Offers of land and of funds for buildings were also received from the citizens of Riverside; but the fact that the coast climate was entirely unrepresented in the work of the station prevented the location of the new substation at this place, where it would have been essentially representative only of citrus culture in the interior. In addition to the three grape culture stations connected with the California Station a fourth has recently been established at Glen Ellen for investigation on the phylloxera and the reconstitution of vineyards.

The North Dakota Agricultural College and Experiment Station was organized in accordance with an act of the State legislature approved March 8, 1890, and is located at Fargo, North Dakota. The station as well as the college is under the control of a board of five directors appointed by the governor with the advice and consent of the State senate. The first director of the station was S. T. Satterthwaite, but he has been recently succeeded by H. E. Stockbridge, Ph. D., formerly director of the Indiana Station. The other members of the station staff are E. B. Waldron, botanist; James Holes, superintendent of farm experiments; Jacob Lowell, general superintendent; E. F. Ladd, chemist. The station has begun experiments with grasses for hay and pasture, varieties of wheat under different methods of cultivation, silage, and sugar-beets. An effort is also being made to collect and classify the injurious grasses and noxious weeds of the State.

The Agricultural College and Experiment Station of New Mexico was established by an act of the legislature of the Territory, passed during the session of 1888-89. The college and the station are located at Las Cruces, and Hiram Hadley, M. A., is president of the college and director of the station. The other members of the station staff are Ainsworth E. Blount, M. A., horticulturist and agriculturist; Elmer O. Wooten, B. S., chemist and botanist. The citizens of Mesilla Valley have donated a farm of 120 acres to the station. Part of the farm was in common crops, cultivated with primitive methods; the rest was virgin soil. Irrigation was necessary. One section of the farm is "mesa" land, above irrigation level, and covered with native mesquite and tornillo. It receives only the scanty rain-fall of that arid region. This has been cleared and reveals a soil of apparently great fertility. The farm has been fenced, irrigating ditches constructed, leveling done, and buildings begun. The land is being planted with common crops to bring it into subjection.

The Agricultural Experiment Station of Utah was founded as a department of the Agricultural College of Utah by an act of the Territorial legislature, approved March 8, 1888. It was not organized until near the end of 1889, and J. W. Sanborn, B. S., was appointed director. The other members of the station staff are W. P. Cutter, B. S., chemist; E. S. Richman, B. S., horticulturist. Five buildings for the use of the station are being erected, a laboratory, bank barn (surrounded by a silo, root cellar, hoghouse, engine-house, and wagon shed), farm and dairy-house, and two cottages. The station is also well equipped with chemical apparatus and farm and horticultural implements. The legislature of the Territory has supplemented the national grants of money by liberal appropriations for buildings, farm tools, and stock. Eighty-five acres are now covered with crops; 40 acres are serving the combined purposes of inquiry and economic farming. The field experiments now in progress include

tests of grasses, clovers, and other forage plants, oats, wheat, corn, barley, sorghum, and sugar-beets; the cultivation of corn, potatoes, and wheat; rotation of crops; tests of fertilizers; and the relative ability of different crops to obtain nitrogen from the air. Box experiments are also being made with reference to soils, evaporation of water, and the growth of various crops. Feeding experiments, meteorological observations, and tests with the dynamometer are also planned. In horticulture, tests of varieties of apples, pears, plums, peaches, cherries, strawberries, raspberries, apricots, and various other fruits, and of vegetables and economic fruit-trees not grown in the Territory have been commenced. Systems of tillage and irrigation will also be tested by the horticultural department.

LINES OF WORK PURSUED BY THE STATIONS.

A classification of the lines of work pursued by the several stations has been attempted in the table on pages 552, 553. The following explanatory statements may serve to help to a clearer understanding of what the stations are doing in the various branches of investigation.

Meteorology and climatology.—Some 25 of the stations are working on these subjects. Some of them simply make observations on the barometric pressure, temperature, humidity, rain-fall, direction and velocity of the wind, etc., and publish the records in bulletins and reports. At others there is an organized weather service, in some instances co-operating with the United States Signal Service. In such cases more complete observations are made and recorded and weather bulletins are sent out. The Alabama Station has recently published a bulletin entitled the climatology of Alabama, in which are contained records extending back more than a century.

Soil.—The investigations of the soil made by the stations are conveniently grouped under three heads: (1) geology, physics, and chemistry; (2) tillage, drainage, and irrigation; (3) action of manures and soil tests.

(1) *Geology.*—Inasmuch as soils vary with the character of the rocks from which they are formed it is desirable to know the history, *i. e.* the geology of the soils of districts in which investigations are being carried on. In so far as the needed information is not supplied by the geological surveys it becomes necessary for the stations to make studies in this line. Thus far, however, but little has been done by the stations. The work is confined to particular localities or to details not included in more general geological surveys. As a rule the experiment station worker will take up his investigation of the soil where the geologist leaves it.

Soil physics.—The fertility of a given soil is decided very largely by its texture, moisture, and temperature. Upon the texture of a soil depend the ease with which it is tilled and the readiness with which air and water and the roots of plants can penetrate it. The principal factors are the fineness of its particles and their character, whether sand, clay, humus, etc. The moisture depends upon not only the rain-fall but also the texture of the surface soil and the Strata below. Temperature and moisture are closely connected. several stations are investigating the texture of soils by mechanical analyses and other means. A number are making regular observations of the temperature of soils at different depths, from an inch to 8 feet, with a view to learning the variations in different sea-

sons and years and under different conditions of rain-fall, drainage, etc., and thus learning more of the relations of soil temperature to plant growth.

Soil chemistry.—Although mere chemical analysis of a soil is not a sufficient basis for judging what kind of fertilizer will be best for it or what crops may be most successfully grown upon it, yet when taken in connection with the physical properties of the soil, chemical analysis is an efficient aid. This is especially true of wide areas of the virgin soils of this country. Investigations in this line are being made by a number of stations, especially by that in California, as stated on pages 498–503.

(2) *Tillage, drainage, and irrigation.*—The effects of different methods of tillage, as harrowing and cultivating, on the mechanical condition of the soil, on its power to absorb and retain moisture and heat and to prevent evaporation, the movements of water in the soil, the rates of outflow from tile drains, the methods for distributing drainage waters with reference to the needs of different soils and crops, and the relations between rain-fall and drainage are among the special problems on which work is being done by the stations. Problems relating to irrigation are being investigated in the States of the West containing large areas of arid lands. The work there undertaken includes not only studies on methods of irrigation but also investigations on special topics, such as the kinds of water suitable or unsuitable for irrigation, or the effects of irrigation and drainage on the alkaline deposits at the surface of the soil, which are in some places disastrous.

(3) *Soil tests with fertilizers.*—It has been found by experience that the most practicable method for finding what fertilizers are best for worn-out soils is to put the question to the soil with different fertilizing materials and get the answer in the crops produced. As it is obviously desirable that such work should be carried on systematically in accordance with well-matured plans, a considerable number of the stations have adopted plans formulated and published by this Office and have enlisted the co-operation of intelligent farmers in different sections of their respective States. These men, working on their own farms under the direction of the stations, have been enabled in many cases to find the needs of their soils and profitable ways to supply them; they have developed capacity for accurate and valuable experimenting, and the educating influence of their work in their communities has been great. An important result of the work in the different regions has been to bring out more clearly than ever before the wide differences in soils and show how they should be studied in order to learn what kinds of tillage, manures, and crops are most advantageous. Of course many of the experiments fail, but the success on the whole has been very considerable. Illustrations are found in the reports of a number of the stations as in those of Connecticut, New Jersey, and Kentucky.

Fertilizers: Analysis, inspection, control.—Throughout the older regions of the country, including the Atlantic and Gulf States and portions of those in the Ohio Valley and some others, phosphates, potash salts, and other commercial fertilizers have become a necessity. The value of these depends mostly upon the fertilizing ingredents, nitrogen, phosphoric acid, and potash, as shown by chemical analysis. So extensive is the use of these articles and so important the testing of their composition that a number of States have on their statute books laws requiring the official inspection of commer-

cial fertilizers. The inspection and analysis are made in some cases by the stations, and in others by State officers appointed for the purpose. In some cases the stations simply make the analyses called for by the law or the necessities of the farmers, while in others the stations collect the samples of fertilizers, make the analyses, publish the results, and if necessary, prosecute parties who violate the laws by either selling fertilizers without statement of composition or selling articles which do not come up to the composition stated. The official inspection, publication of analyses, and prosecutions where called for are included in what is commonly called fertilizer control.

Field experiments with fertilizers.—Besides the experiments for soil tests above referred to, the stations conduct field trials to test the effects of fertilizers upon staple crops, vegetables, fruit-trees, or special crops in particular localities. The proper methods for applying fertilizers also receive attention.

Crops: Composition, manuring and cultivation, varieties, rotation.—Under these heads are included studies of the more important crops, such as corn, oats, wheat, potatoes, tobacco. Analyses are made to determine the composition of the plants and of their differents parts, as grasses, hays, and the kernels and stalks of corn. By such means light is obtained regarding not only the character of the product but also the best time and methods of growing and of harvesting. Different methods of manuring and cultivating are also being tested, and at some stations systems of rotation of crops are being tried with a special view of introducing greater diversity in the agriculture of some localities. An important part of the stations' work with crops is the testing of the merits of different varieties of grains, vegetables, fruits, etc. The tendency to improper naming of varieties and the selling of old varieties under new names has led the stations to take steps toward the adoption of systematic rules for nomenclature.

Feeding stuffs: Composition, digestibility.—The stations are making many analyses of the feeding stuffs used in their respective localities as a means of judging of their nutritive values and the best ways to use them. To a similar end the materials are used in feeding experiments with different kinds of animals. The digestibility of the feeding stuffs is studied both by laboratory experiments and by feeding them to animals.

Silos and silage.—Many stations are studying such questions as the location and construction of silos, the kinds of crops suitable for silage, and at what stage of growth they should be harvested, methods of storing the silage, the changes in silage brought about by the fermentation arising from the action of bacteria and other causes, the effects of silage on the growth of animals and on the quantity and quality of milk and butter.

Feeding of animals.—Thirty-one stations are conducting feeding experiments for milk, beef, mutton, or pork, or are studying methods of experimenting. Among the questions considered are the effects of different feeding stuffs and rations upon the quantity and quality of milk yielded by cows, upon the flesh, muscle, and bone of beef, and upon the lean and fat of pork, etc. The manurial value of different feeding stuffs is also taken into account. Not only are diferent breeds of animals compared, but of late more and more attention is being paid to individual differences in animals of the same breed. It is already clear that individual peculiarities are often of more consequence than breed distinctions, and that the farmer

should not only be careful to choose animals according to the purpose he has in view in keeping them, but should also keep a close watch on each animal and get rid of the unprofitable ones.

Feeding experiments are comparatively expensive and require the able management of experts for satisfactory results. Plans are now under consideration by which it is hoped, through the co-operation of the stations, to secure better methods of investigation and to study special problems by experiments with large numbers of animals. Much help in this line of work has been received, and more is expected, from individual and associated breeders and dairymen in different parts of the country.

Dairying.—Not only is the feeding of dairy animals above referred to an important part of station work, but many special investigations are in progress on the composition of milk, the influence of minute organisms (bacteria) on the souring and creaming of milk, the devising or testing of different methods for the raising of cream and the making of butter and cheese. In several States special attention has been devoted to creameries. Much has been done by the stations to promote paying for the milk delivered to creameries according to its quality as well as its quantity. As an aid in this direction much ingenuity has been exercised in devising simple, inexpensive, and accurate methods of testing the proportion of butter fat in milk. Several such methods have already been devised and are more or less widely used. They promise to be very serviceable to dairymen in testing the quality of the milk of individual cows and getting rid of the unprofitable ones. A brief account of these "milk tests" is given on pages 527–536 of this report.

Chemistry.—As already indicated, a very large amount of chemical work is done by the stations in the analysis of soils, fertilizers, feeding stuffs, and foods. Besides this they are called upon to make many analyses of other things, as waters and minerals.

Not content to work in routine ways the chemists are continually devising new and better apparatus, improving the methods of analysis, and pushing their researches into the higher fields of inquiry. Through the Association of Official Agricultural Chemists systematic co-operation in this work is secured.

Botany.—While most of the work of the stations which relates to plants might be included under this head, it is convenient for our present purposes to make this term embrace only studies on the general classification of plants, vegetable physiology, plant diseases (mycology), seeds, and weeds. In our newer and some of our older States much remains to be done in the systematic collection and study of species of grasses, and other plants which may be useful in agriculture. The problems relating to vegetable physiology, *i. e.* to the ways in which plants live, are nourished, and grow, have as yet received comparatively little attention in this country. In both these lines the stations are making a beginning of useful investigations. There is now considerable activity in the study of the diseases of plants, especially those due to the action of fungi. New species of fungi have been discovered, and the life history of many formerly known has been traced out. Attention is also given to the devising and applications of remedies, especially fungicides. Much useful work in this line has been done by the stations during the past year.

The testing of seeds as regards their purity and vitality has been a part of the work of 25 stations. These tests are made in appro-

priate apparatus, in the greenhouse, and also in the garden and field.

The study of species of weeds as to their prevalence, ability to rob the soil, seed-producing capacity, the dissemination and vitality of the seed, propagation by roots or stems, poisonous or other obnoxious qualities, methods for their eradication, etc., has been undertaken to a limited extent.

Horticulture.—The work of the stations in horticulture has thus far consisted very largely in the testing of new varieties of vegetables and large and small fruits, or of old varieties with reference to their introduction in localities where they have not been grown hitherto. To facilitate this work and make its results of general use the stations have co-operated with this Office in establishing uniform conditions and methods for such tests and in bringing their work to the attention of originators of new varieties in order that as far as practicable such varieties may be carefully tested by the stations before they are offered to the public. One important feature of this horticultural work has been the detecting of identical varieties which are innocently or fraudulently distributed under different names. While much still remains to be done to systematize variety testing and to bring order out of the present confusion, the horticulturists of the stations are rightly unwilling to confine their operations to this line alone and are doing a considerable amount of work with reference to the improvement of varieties by selection of seeds and plants and by cross-fertilization.

Forestry.—Twenty stations have begun operations in forestry. The work thus far done has been mainly the planting of different varieties of forest-trees to test their adaptability to the climate and needs of particular sections. A similar line of work has been undertaken with trees suitable for wind-breaks.

Entomology.—Thirty-one stations investigate injurious insects with a view to their restriction or destruction. A portion of the work includes the tracing of the life history of insects, the kind of plants they injure, and the ways in which this injury is done. A great deal of attention has recently been paid to the use of insecticides, such as Paris green, London purple, and white arsenic, with the aid of spraying apparatus or otherwise for the destruction of injurious insects. The experiments have included the tests of various substances with reference to their effects not only upon insects but also upon the foliage of different kinds of plants.

Apiculture and aviculture.—Problems relating to the raising, housing, and general care of bees and poultry are being studied by several of the stations.

Veterinary science and practice.—The investigations in this line have reference to the causes, symptoms, and treatment of animal diseases. Such diseases as hog cholera, Texas fever, and tuberculosis have received the most attention. Experiments have also been made with reference to the effects of such operations as dehorning and spaying and the methods of performing the operations.

Technology.—Under this head are included experiments in the making of sugar from cane, beets, or sorghum, wine making, etc. The Louisiana Sugar Experiment Station has been the most active in experiments on the production of sugar from cane, and the California Station in investigations on wine making. The cultivation of sorghum and sugar-beets, and the production of sugar from them is now occupying the attention of several stations.

While collectively the work of the stations covers a very wide range, individual stations for the most part limit their work to a comparatively small number of topics. The experience of our stations is already teaching the lesson which the European stations learned long ago, that a few subjects well studied are preferable to many with less thorough work. Some stations have, therefore, recently given up lines of work in which they found by experience they could not profitably engage. On the other hand, increase in resources has enabled some stations to establish new departments of investigation.

ILLUSTRATIONS OF STATION WORK.

The following statements, compiled from reports of the work of the stations received by this Office in 1890, may serve to indicate the nature and value of their experimental inquiries as illustrated by their practical outcome. Of course no attempt has been made to cover all the points of interest or value presented by the current record of a year's work of the stations. The object is simply to indicate some of the ways in which the stations are endeavoring to aid the farmer. For a more complete showing of the scientific character and practical utility of such work resort must be had to the bulletins and reports of the stations and to those publications of this Office in which the station publications are summarized, especially the Digest of Annual Reports and the Experiment Station Record. In the references to station publications given in this report in foot-notes, each station is designated by the name of the State in which it is located, *e. g.*, New York (Cornell) Station Bulletin No. 5 means Bulletin No. 5 of the Cornell University Agricultural Experiment Station at Ithaca, New York. A full list of the stations, with addresses is, given on pages 548 and 549.

CORN.

Experiments with corn at the Illinois Station* have led to the following among other conclusions:

Not to exclude other meritorious varieties, the following medium-maturing dent varieties may be safely recommended for general culture in Central Illinois: Yellow—Leaming, Clark's Iroquois, Legal Tender, Riley's Favorite, Fisk. White—Champion White Pearl or Burr's White, Gourd-Seed, Clark's Premium 110-Day. The following, which are desirable early-maturing varieties in this latitude, may be recommended for general culture in Northern Illinois: Yellow—Murdock, Edmonds or Kane County Pride, Grange Favorite, King of the Earliest (for very early). White—Wisconsin White Dent, Champion of the North.

The following, which are almost too late for this latitude, would probably be desirable farther south: Yellow—Improved Orange Pride, Steward's Improved Yellow, Swengel. White—Helm's Improved, Parrish.

There are many good varieties of Indian corn for this latitude. No one variety tested was noticeably superior to all others.

Such phrases as "ninety-day" or one-hundred-day" corn are misleading, if meant to teach that ordinary field corn will fully mature in average seasons in this latitude in the number of days named. The early-maturing varieties required one hundred and twenty-five days or more to mature fully.

The medium-maturing varieties, or those maturing about September 25, gave larger yields of well-dried corn than either earlier or later varieties.

Thoroughly air-dried corn contains about 11 per cent of water in the shelled grain. The loss in weight after husking is greater than is generally recognized. It may be from 10 to 20 per cent. Eighty pounds of ear corn, as husked, of the medium-maturing varieties, would not make more than a bushel of air-dry corn.

Barrenness of the stalk seems to depend much more on the conditions under which the crop is grown, as thickness of planting and the season, than on the variety.

*Illinois Station, Bulletin No. 8, G. E. Morrow.

The date of planting within the limits ordinarily fixed for corn planting in this latitude had little influence on the yield of a medium-maturing variety.

Depth of planting did not materially affect the yield either in 1888 or 1889. In the latter year the roots which supported the plant during the most of its growth usually started within 2 inches of the surface, whatever the depth of planting. Unless the soil near the surface has not sufficient moisture, there seems to be no good reason for planting corn in this region more than about 3 inches deep. Drill planting was not found materially better than hill planting either for the production of corn or fodder. The quantity of seed planted controlled the yield, rather than planting one or four kernels in a place. For corn alone, planting at the rate of one kernel every 9 or 12 inches gave better results than thicker or thinner planting. For fodder, planting at the rate of one kernel every 6 inches gave better results than planting twice as many kernels.

Stirring or cultivating the soil while the crop is growing was not essential in either 1888 or 1889. Good yields of corn were obtained where there was no cultivation after planting, except to remove the weeds by scraping the surface.

Preventing the growth of weeds was more important than stirring the soil.

Root pruning injured the crop. Stirring the soil to a depth of 4 inches or more will injure many roots of the corn. Comparatively few roots will be affected if the soil is not stirred more than 2 inches deep.

Shallow-working cultivators gave better results than deep-working ones, but required more care and skill in their use. The deep-working shovel cultivators killed the weeds more thoroughly than the shallow-working ones, but the latter injured the roots less. Usually, frequent cultivation did not repay the extra cost.

Commercial fertilizers failed to increase materially the yield of either corn or fodder in any one of nine trials. The soil apparently had a sufficient supply of the plant food that these fertilizers furnish.

Stable manures increased the yield of corn and fodder in most cases, but not always enough in one year to repay certainly the cost. Fair crops were produced on land which had been in corn for fourteen years without manure of any kind. For like soils in Illinois, the estimates often made of the value of either commercial or barn-yard fertilizers, based on the price at which the elements of plant food contained by them can be bought, are misleading.

The yield of most varieties, and the average yields of all, in 1888 and 1889, were above the average reached by good farmers in field culture. Probably the chief reasons for this result were that the varieties were better than the average; that more than usual care was taken to secure a good seed bed and to plant well, thus securing a good and uniform stand; and that the cultivation was more careful than in average field culture.

Experiments with corn have been carried on for a number of years at the Ohio Station,* from which the following conclusions, especially applicable in that State, have been drawn:

(1) Considering the several varieties of corn, according to our present classification, the large yellow dent varieties, as a class, are most productive. Large white dents take second place, followed by medium yellow dents, mixed dents, and medium white dents in the order named.

(2) In the flint varieties the large white flints take the lead, followed by mixed flints, and these by yellow flints.

(3) Taken as a whole or as individual varieties, the flint varieties are not a profitable class for Ohio land, unless it should be in some of the northern sections. The following are noted as failures at the station: Smut Nose, Top-Over, Hudson Bay, Angel of Midnight, Chadwick, Tuscarora, and King Philip.

(4) The soft or flour corns have failed to mature in the tests of the last two years. To grow them for stock-feeding purposes would not be profitable, and if they are valuable for house use their failure to mature prevents their general adoption in this latitude.

(5) Any of the large yellow dent varieties will give fair yields, but the ones more certain of maturing are the Leaming, Murdock's Improved, and Woodworth's. The Chester County Mammoth, Cloud's Early Dent, and Golden Beauty are quite uncertain, but when they mature they are fine varieties and good producers.

(6) Among the medium yellow dents the Clarage and Farmer's Favorite are recommended. Either of these is ten days earlier than any of the large yellow dents, and is probably better adapted to the more northern parts of the State.

* Ohio Station, Bulletin Vol. III, No. 3, J. F. Hickman.

(7) Of the large white dents Hess's White is a good variety for gravelly loam soils or other soils of a gravelly nature. The Champion Early Pearl has done fairly well this year and promises to be a good variety.

(8) In seven years' experiments with deep and shallow planting the average results show an advantage in favor of planting 1 inch rather than 2 inches deep, but indicate that in dry seasons it may be better to plant 2 inches deep.

(9) The greatest amount of marketable corn has been produced where the stalks averaged 12 inches apart; the variations in yield were slight, whether planted one grain every 12 inches, two every 24, three every 36, or four every 48 inches.

(10) Three years' trial has not indicated any marked differences in the reproductive qualities of corn from the butts, middles, or tips of the ears. If there is any variation it is in favor of middles and tips and against the butts.

(11) The experiments of 1888 and 1889 indicate that corn should be cultivated more frequently in a dry season than in a wet or ordinary one.

(12) The average results of two years' experiments favor deep cultivation rather than shallow. The implements used were the harrow and cultivator for shallow tillage and the double shovel for deep.

Experiments were conducted at the Pennsylvania Station* in 1888 and 1889 to study the adaptability of some varieties of field corn to this section, and also to make observations upon the yield of the corn plant at different stages of its growth.

The Self-Husking variety was the earliest of the flints. The Queen of the North, Wisconsin Earliest White Dent, Minnesota King, Leaming, Queen of the Prairie, and Cleaver were the dents which matured. They are named in the order in which they matured. The Golden Beauty, Golden Dent, Hickory King, and Champion White Pearl can not be recommended for cultivation for grain in our section. In the southern part of the State and in many of the river valleys they may be grown. They are named in order of earliness, although there is but slight difference between them. They would be much earlier than the larger varieties, Chester County Mammoth, Mammoth White Surprise, and White Giant Normandy, grown here in 1888.

[As regards the distribution of dry matter (actual food matter) in different parts of the plants, the results obtained from the field-cured samples show that] fully half of the valuable dry matter is in the ears, and of this nearly one fifth is in the cob. The leaves and husks contain from one fourth to one third of the total, and there are four to five times as much of the remainder in the butts or harder and tougher parts as in the tops. Thus, when fodder is fed whole, there is more or less waste of the butts by the animal. From our results it would seem that this loss would be from 7 to 22 pounds in every 100 pounds of dry matter. Practical experience proves that much of this may be saved by cutting up the cured fodder or putting it in the silo.

The experiments at this and the Kansas Station and elsewhere have shown that much of the dry matter of the corn crop is lost by harvesting before the corn is mature; for example, the average of the dent varieties grown at the Pennsylvania Station during two seasons shows a gain of nearly one fifth of the total amount of dry matter by allowing plants to mature.

WHEAT.

Experiments in wheat seeding.†—During nine years in which rates of seeding, ranging from 2 to 10 pecks per acre, have been tried at the Ohio Station the 7-peck rate has given the highest average yield, but is closely followed by the 5 and 6-peck rates. With a single slight exception the highest yields have been produced for seven years from seeding during the last week in September and the first week in October. In experiments covering five seasons better yields have been obtained from seeding 1½ to 2 inches deep than from shallower or deeper planting.

* Pennsylvania Station, Bulletin No. 11, W. H. Caldwell.
† Ohio Station, Bulletin Vol. III, No. 6, J. F. Hickman.

Varieties of wheat.—Among the varieties grown at the Ohio Station for six years the following are especially commended:

The Valley, Nigger, Penquite's Velvet Chaff, and Diehl Mediterranean among the red-bearded wheats; of the smooth red wheats, the Red Fultz, Poole, and Finley; of white wheats, Silver Chaff (smooth), Royal Australian (Clawson), Martin's Amber, and Democrat.

The director of the station makes the following statements regarding certain varieties of wheat which have received different names:

Sibley's New Golden and Tasmanian Red appear to be the old Mediterranean under new names. Reliable, Valley, and Egyptian closely resemble each other in the field, but show slight differences in the grain. We have not been able to distinguish Red Fultz and German Emperor from Michigan Amber. Poole resembles these closely, but is distinct. Witter was classed with them last year, but is distinct and inferior. The only point of distinction we have yet found between Hungarian and Geneva is the excessive smuttiness of the former. Diehl Mediterranean, Golden Cross, Missouri Blue Stem, and Seneca Chief are one and the same variety. Royal Australian is the old Clawson under a new and high-sounding name. Finley and Fultz are not distinguishable, whether in the field or granary. Silver Chaff, Martin's Amber, and Landreth resemble each other so closely that we can not yet describe their points of difference, if they have any. Martin's Amber may prove to be slightly different after further comparison. Of other varieties we are yet in doubt. It is not always possible to decide positively whether two differently named lots of wheat are identical or otherwise from a single season's observations, especially if the seed has been obtained from different localities.

Bearded vs. smooth and red vs. white wheat.—During the past ten years ninety-five trials of white wheats and three hundred and thirteen of red wheats have been made at the Ohio Station.

The average yield per acre for the white wheats has been 30.8 bushels per acre, while the greater number of red wheats have averaged 31.5 bushels per acre for this series of ten years. During the ten years one hundred and sixty-two trials of bearded wheats have been made, giving an average of 31.7 bushels per acre, while two hundred and thirty-four trials of smooth wheats have given an average of 31.1 bushels.

The differences in the yields of these different classes of wheat in so many trials, covering such a long period, are so slight as to indicate that under the conditions prevailing at this station one kind is about as reliable as another.

Frosted and rusted wheat.—The Minnesota Station* has been studying the effect of frost, rust, and other injurious agencies upon the value of wheat for milling and for sowing. The smoother the hull of wheat the more easily and economically can it be milled, and if for any reason the hull has been seriously injured the value of the wheat for making "patent" flour is decreased. Injuries to the hull may not affect the germ or the interior of the grain, so that wheat which grades low for milling may be of good quality for seed. In 1888 much of the wheat failed to grade high for milling, and was, therefore, indiscriminately classed as "poor wheat." When this poor wheat was used for seed it sometimes yielded good crops and sometimes failed to produce any crop. In many cases this difference in results was thought to be purely accidental, or in case differences in the seed used were observed, poor returns were attributed to a lack of vitality in the injured grain or to the slow growth of grain from "frozen" seed. But the fact generally lost sight of was that the causes which produce "poor wheat" are different in different cases, so that really there are more or less distinct classes of such wheat, which, if used for seed, will give diverse results. Dr. Har-

* Minnesota Station, Bulletins Nos. 5, 6, 7, and 11, E. D. Porter and D. N. Harper.

per, chemist of the Minnesota Station, has attempted a classification of the varieties of "poor wheat," according to the cause of the injury to the grain, into bleached, rusted, blistered, and frozen wheat.

Bleached wheat is defined as wheat which, after harvest, has been exposed to rains and the heat of the sun until the outer envelope of the grain is opaque and brittle. Ordinarily this does not affect the usefulness of the wheat for seed.

Rusted or blighted wheat is more or less shrunken in appearance, and is usually of a deeper amber color than is normal. "It is a poor wheat for milling because of the bad condition of the hull," but if not too much injured may be used for seed, as is indicated by the results of experiments.

Blistered wheat retains its normal amber color, but has a brittle hull, and in many cases contains more gluten and protein and less starch than sound wheat. "As blisters may be caused by other means than frost, and even after the wheat is cut, it is not correct to call all such wheat frosted." Except in extreme cases it may be safely used for seed if well cleaned. Cured wheat is not affected by the lowest temperature which occurs in Minnesota, but a temperature only a few degrees below freezing affects immature and uncured wheat. "Wheat well into the 'dough' stage, if subjected to a temperature below freezing, may be blistered (frosted), but when 'in the milk' the same temperature produces frozen wheat."

Frozen wheat "is badly shrunken, has lost the normal translucent amber color, is of an opaque, bronzed appearance, and has had the composition of its chemical constituents changed, as well as the internal structure of its cells destroyed." The grain contains less gluten, and the quality of the gluten is seemingly injured. In other words it appears that the material in the wheat which gives tenacity to the flour is so altered that the quality of the flour made from frozen wheat is poor. Such wheat deteriorates greatly after being harvested. When used for seed the crop is unfit for milling. Fermentation may set in later on and the chemical constituents be further changed, as was the case in Minnesota during the winter of 1888–89, so that the frozen wheat when planted in the spring was in a much worse condition than when harvested the previous fall. In the majority of cases, however, the frozen seed germinated and produced wheat having the characteristics of the seed from which it sprung. It was also observed that the difference between the crop from sound seed and that from frozen seed was not marked until after the wheat was harvested.

The desirability of cleaning the "poor wheat" to be used for seed has been shown in the experience of numerous farmers. "Indeed, in many cases seed from very poor wheat when cleaned has yielded better than wheat originally good but uncleaned. The density of wheat must largely determine its value for seed."

As the outcome of his investigations and his observations of the results of experiments by farmers Dr. Harper draws the following conclusions:

(1) A vast difference as to their seed value exists between the various kinds of "poor wheat."

(2) Rusted or blistered (frosted) wheat, if well cleaned, is safe to use for seed.

(3) Frozen wheat, which is utterly worthless for milling, is likewise of no value for seed. It can not produce a good crop.

(4) The more thoroughly wheat is cleaned the better the seed resulting and the better the crop, particularly in yield; and by cleaning I mean, besides separating the dirt, also casting out the weaker grains of wheat. Thus poor milling wheat may

be made vastly better for seed than wheat of high milling value if the latter is uncleaned.

(5) Wheat should invariably be tested as regards its gluten and percentage of germination before being seeded. It seems absolutely necessary that the seed shall contain good gluten if the gluten is to be in the crop. * * *

To most successfully carry on the mechanical operations of milling it is first necessary to have plump wheat in which the hull has not been injured. Then the best flour, after the hull is gotten rid of, is made of that wheat which contains the most gluten and the least water. Other conditions of the wheat also enter as a factor.

To grow the best crops the first necessity is to have the germ of the wheat sound and then to have compactly stored up plenty of the proper kind of food—gluten, etc. Outside influences may cause the hull to be uneven or brittle without injuriously affecting the germ and its food; and this wrinkling of the hull may not be a property which will be transmitted by the seed to the crop, although in some cases it doubtless is. But certain changes in the character of the germ and its food are unmistakably transmitted. In blistered, rusted, and bleached wheats the superficial characteristics of the wheat are changed, while in frozen wheat changes seem to have been made in the reproductive faculties.

In any lot of wheat, even of the highest grade, some grains are vastly better than others for seed, and it is a simple matter to determine which they are and how to secure them. If it had not been clearly proven before, the last wheat crop has conclusively shown that the denser any grain of wheat the better it is for seed. These are the grains which are the heaviest for their size. If wheat is well cleaned by a blast of wind the lightest grains are cast out and the heaviest remain. In these the germ is best developed and protected and has most readily available the greatest amount of necessary food. Of this gluten is of chief importance and its quantity and quality can be easily determined.

The following method has been used by Dr. Harper for roughly determining the amount of gluten in samples of wheat. The wheat is first ground as fine as possible in a copper mill and then pounded in a mortar, care being taken to break up the hull or bran as little as possible. This finely ground wheat, after being weighed, is mixed in a porcelain dish with enough water to make a good dough. The dough is placed in a linen bag and let stand in water for a few minutes until it is thoroughly wet. Then by letting water run on the bag the starch is partially washed out. The wheat is then taken out of the bag and held in the hand, under running water, over a fine sieve. By this means the starch or bran is largely washed away and the remaining substance, when dried and weighed, may be safely reckoned as the gluten of the wheat. The dry gluten should weigh at least one tenth as much as the original sample of wheat. The test outlined above indicates also the quality of the gluten, for unless the wheat is in good condition the gluten cannot be separated by this process of "washing out."

*Stinking smut of wheat.**—Fifty-one different methods of treating stinking smut of wheat have been tried at the Kansas Station in 1890. Three of these treatments, viz, copper sulphate, 5 per cent solution, applied for twenty-four hours, Bordeaux mixture, thirty-six hours, and potassium bichromate, 5 per cent solution, twenty hours, prevented all the smut, though these fungicides injured the stand of the wheat somewhat. However, in spite of this injury they increased the yield to two or three times that of untreated plats. Of all the treatments tested that known as the Jensen or hot-water treatment is deemed perhaps the best for general use, though in these experiments it did not prevent all the smut. However, when used in its most favorable form only 5 heads out of 3,912 were smutted, and it is probable that these were accidental, since they grew on two hills on the edge of the field. This treatment was devised by J. S. Jensen,

* Kansas Station, Bulletin No. 12, W. A. Kellerman and W. T. Swingle.

of Denmark, and consists in immersing the seed for fifteen minutes in scalding water (131° to 132° F.).

COTTON.

Ten stations have reported experiments or observations on cotton, including those relating to the conditions of climate and soil favorable to its growth; the development of the roots; varieties; seeds; fertilizers; methods of planting and cultivation; and diseases injuring this plant.

Meteorological conditions favorable to cotton.—The results of studies on this subject were published in Bulletin No. 7 of the South Carolina Station, from which the following statements are compiled: Two periods in the growth of the cotton plant may be distinguished. The first extends from the time of planting, which in South Carolina is about the middle of April, to the middle of the summer. This is the time in which the plant makes its growth of stalk and foliage and gathers up nourishment to be later transferred and stored up in the seed. During this period tropical conditions are favorable, namely, moisture in the soil from frequent rather than long-continued rain, high temperature with small daily variation, plenty of sunshine, little wind, and a high relative humidity of the atmosphere to reduce evaporation to a minimum. During this period everything possible is done to prevent loss of water from the soil; grass and weeds are scrupulously excluded, and the surface of the soil is frequently stirred with the hoe or otherwise to conserve the moisture and increase the temperature of the soil.

Now, if these conditions of high temperature and large proportions of moisture in the soil continue the plant will keep on growing and developing stalk, will become perennial, and will produce only the coarser grades and smaller yield of cotton found in many tropical countries. But the meteorological conditions change and the plant goes through a second period of development. In the latter part of the season in South Carolina the temperature rapidly falls, the rain-fall diminishes, the plant is changed from a perennial to an annual, the yield of cotton is increased, and the quality of the lint is improved. The second period is the fruiting period of the crop, when all the energies of the crop are turned to the ripening of the fruit. During this period the physical properties and conditions of the soil have an important effect upon the crop production. It then becomes important to ripen the crop and to produce the fruit instead of the stalk and foliage; in other words, cotton instead of weed. Every means is taken to dry out the soil, cultivation ceases, and the soil is allowed to become hard and compact to favor the evaporation of the moisture. Grass and weeds are no longer feared, and rye and barley are frequently sown during the last part of the season, being supposed by many to be of value for drying out the soil. In the stiff soils or in the bottom-lands there is often an excess of moisture, and the crop is inclined to mature late and often fails to open before frost.

On the islands and in the country immediately adjoining the coast the fine grades of sea-island cotton are produced. In the lower pine belt, which is farther back from the coast and on the ridge lands, the cotton is coarser. It is urged that differences in moisture and temperature account for these differences in the crop; that the finer grades of cotton are produced only where the physical conditions of

atmosphere, and especially of soils, are fitted for the development of the weed in the early part of the season and of the fruit in the later part, and that in some cases physical conditions of the soil have been so improved by tillage as to make a very marked difference in the crop. It is therefore important to study the differences in physical characters of the soils, with a view to getting light upon the means by which the systems of tillage and culture may be so regulated as to adapt temperature and moisture of the soil to the successful growth of the finer grades of cotton over larger areas.

On the development of cotton roots.—The same bulletin also treats of this subject. The root system of the cotton plant is naturally small and the individual roots are small and delicate. After the first picking of cotton eight plants which had grown on light, sandy soil, having sandy subsoil, were dug up and examined. The tap-roots extended "straight down below 2 or 3 feet." The lateral roots commenced about 3 inches below the surface and for the most part did not go below 9 inches. Out of more than twenty plants grown on heavier loam soil, with compact subsoil, only one was found with well-developed tap-root below 9 inches. Most of the lateral roots commenced and were contained within 3 to 9 inches of the surface.

Varieties of cotton.—In a single test of eleven varieties reported from Alabama* Peerless led in early maturing, and in yield (1,080 pounds per acre) was equaled only by Jones's Improved, though closely followed by Welborn's Pet and Zellner.

In the case of twelve varieties tested at the Alabama Canebrake Station* Okra was the first to blossom and open, and produced the greatest amount of seed cotton the first picking, but less than others the second and third pickings. Zellner, Barnett, and Jones's Improved produced the greatest yields of lint and seed, the last named being hard to gin. At the Louisiana State Station* in 1888, out of thirty-eight varieties the largest yields of seed and lint were given by Jones's Improved, Herlong, and Dearing's Small Seed. In nearly every case the yields of the same varieties at this station were smaller than those at the North Louisiana Station. At the Arkansas Station, out of eight varieties reported, Crawford and Peerless gave the largest yields of seed cotton. The five varieties giving the highest average yields of lint in 1888 and 1889 at the three farms of the South Carolina Station* were Rio Grande (synonyms Texas Wood, Peterkin, Crosland), Truitt, Dearing, Minter's, and Crawford.

At the Alabama College Station* samples of cotton representing eighteen varieties grown on the station farm—sea-island cotton from Savannah, Georgia, and "Bailey" fiber from North Carolina—were examined microscopically. Among the questions considered were: "(1) How many real varieties of cotton exist? (2) In forcing the plant under high cultivation is the fiber improved, or is simply the 'weed' enlarged to the detriment of the staple? Is it not often the case that the fruit of the cotton plant is damaged by too rapid maturing, just as the fruit of the peach is known to be immature at the center in some early forced varieties?" The experiments indicate "that it is not always the large plant that produces the best condition of the fiber, and that the most excellent condition of the fiber is produced only on plants which are neither too rapid nor too slow in their development, and which are given all the advantages of judicious cultivation with

* Alabama College Stations, Bulletins Nos. 12 and 13; Alabama Canebrake Station, Bulletin No. 7; Louisiana Stations, Bulletin No. 26; South Carolina Station, Annual Report for 1889, p. 275.

the proper manuring and under the most favorable conditions of the atmosphere. In improving the grade of cotton the plant must be forced to produce fiber that is (1) long, and as nearly as possible uniform in length; (2) of uniform diameter throughout; (3) flat and ribbon-like, and well twisted." Seed selection should be repeated from year to year, and no inferior cotton planted near enough to vitiate the chosen variety with its pollen. In these experiments the strongest fiber was produced by the Truitt variety; the largest by Barnett; the smallest by No. 1, Hawkins' Improved and Peterkin; the longest by Okra Leaf; the shortest by No. 2; and the best twisted by Truitt, Rameses, and Cherry's Cluster.

"The largest percentage of fiber per boll was produced by Welborn's Pet, Okra Leaf, Peterkin, Hawkins' Improved, and King's Improved, in the order named. The largest percentage of seed per boll was produced by Zellner, Rameses, Southern Hope, and Truitt, in the order named. The best grade of cotton, taking all things into consideration, is Cherry's Cluster. The second best grade is Truitt."

Comparative earliness of cotton from Northern-grown seed.—At the Alabama Canebrake Station* an experiment was made in the endeavor to find a "variety from some Northern point that would mature a crop before attacked by the worms. Seeds were obtained from Somerville, Tennessee; Carter's, Northern Georgia; and Raleigh, North Carolina. The seeds from North Carolina were of an improved variety, and those from North Georgia and Tennessee were common. They were planted March 28, on one-third-acre plats, in black slough bottom-land." The results from these seeds were sufficiently better than those from seeds grown at the station to justify a repetition of the experiment.

Fertilizers for cotton.—Experiments on the poor, sandy soils of the three farms of the South Carolina Station† in 1888 and 1889 indicated "that marl and copperas produced no effect upon the crop; that separate applications of potash, phosphoric acid, and nitrogen were equally valueless; that their combinations produced marked effects; that phosphoric acid and nitrogen played the most important parts; that potash was of relatively less value than the other two; that excessive applications of one or all three gave no adequate returns."

Of nitrogenous fertilizers stable manure gave the best results, while those obtained from nitrate of soda, dried blood, cotton-seed meal, and cotton seed were nearly equal. In nearly every case the half ration of nitrogen gave as good results as the full ration.

Acid phosphate proved more effective than reduced phosphate, which in turn gave better results than slag and floats.

Kainit and muriate and sulphate of potash gave equally good results. As a rule kainit would be preferred on account of its relative cheapness.

In Arkansas ‡ potash and phosphoric acid were profitably used in experiments in 1888 at Texarkana and Lufra; nitrogen, potash, and phosphoric acid, at Monticello; and nitrogen (in cotton-seed meal) at Pine Bluff, on land which had been almost continuously in cotton for thirty years.

In Alabama‡ experiments on sandy loam soil with clay subsoil indicated that phosphoric acid was the fertilizer especially needed.

---

*Alabama Canebrake Station, Bulletin No. 7.

† South Carolina Station, Annual Report for 1889.

‡ Arkansas Station, Annual Report for 1889; Alabama College Station, Bulletin No. 12.

At the North Louisiana Station* experiments have indicated that these particular soils need nitrogen very badly, but it is not so clear which is the best form to use. Cotton-seed meal gave results slightly better than any of the others, with cotton seed next. This, of course, simply tends to show that cotton seed or cotton-seed meal is a good form in which to apply the nitrogen, without prejudice to the claims of other forms, which may be excellent in their way. From a financial standpoint it seems probable that more than 24 pounds of nitrogen per acre can not be used with profit, especially on very poor soils. It also seemed probable that phosphoric acid in small quantities might profitably be applied to the soil used in the experiments. Potash apparently was not needed.

Pea vines as a fertilizer for cotton.—At the Alabama Canebrake Station† the results of experiments during the past five years have strongly favored the use of pea vines to restore fertility to worn-out soils, and implied that it is better to cut the vines for hay than to leave them on the ground. The increased yield by leaving the vines is small, and the land is much harder to prepare where the vines are left. From 2 to 5 tons of hay can be cut from 1 acre in vines. The increased cotton grown by leaving the vines to rot on the land was worth only $8.75 per acre, while the vines cured into hay would be worth not less than three times that sum. The effect of the vines upon crops after the first season has not been ascertained.

Cotton root rot.—The Texas Station has made a study of this disease and reported the results in Bulletin No. 7, from which the following statements are compiled: Root rot of cotton occurs in soils of various kinds, but is worse in black, cretaceous soils which are poorly drained. Moisture and heat are favorable to its development, but the character of the forest growth has nothing to do with this disease. "It occurs alike on the mesquite soils of Travis and Hays Counties and the post-oak lands of Eastern and the bois d'arc lands of Northern Texas." Theories as to its origin founded on the chemical constituents of soils and especially on the "alkali" present in many soils, are not sustained by the facts. Alkali, as the term is used, is very vague, and does not apply to the Texas soils where cotton dies from root rot. In California cotton succeeds admirably on "alkali" soils, while fibrous-rooted plants do not thrive on such lands. In Texas, on the other hand, the fibrous-rooted plants, like grasses, do not die from root rot. "Seedling rot" and "sore shin" should not be confounded with root rot. "Seedling rot" affects only young plants.

Root rot of cotton is caused by a fungus, *Ozonium auricomum*, invariably found on roots which have died from this disease. If plants are examined before they have wilted a white, mold-like fungus, the early stage of *Ozonium*, will be found on the surface of the roots. Young plants in pots inoculated with threads of the *Ozonium* died of the disease. The wart-like bodies found on the roots of cotton and other plants affected are masses of the fungus and retain vitality for a long time. The *Ozonium* does not, however, produce the knotty bodies often found on the roots of diseased apple-trees. A large number of plants are affected by this fungus, as sweet-potatoes, apple and some forest-trees, and also the weed known as common sida (*Sida spinosa*). The *Ozonium* prepares the way for a large num-

*Louisiana Stations, Bulletin No. 27.
†Alabama Canebrake Station, Bulletin No. 7.

ber of other fungi, which complete the destruction begun by the root rot. The lint from plants affected with root rot is much inferior in quality. Seeds from diseased stalks showed good capacity for germination.

Treatment.—Fungicides did not check the disease, except chloride of lime, and where this was used no cotton was produced. Rotation of crops is advised as practically the only thing, so far as known, which will stop the disease. Grasses should be grown in the rotation, allowing three years to intervene before cotton is again planted. Care should be taken not to obtain plants from an infected nursery or field.

LEGUMINOUS PLANTS.

During 1890 the Connecticut Storrs Station* has reported the results of experiments with different varieties of leguminous plants with regard to their value in Connecticut for hay and green fodder for manurial purposes. The following summary of practical conclusions is taken from Bulletin No. 6 of this station:

The legumes are especially valuable because of—

(1) Their large percentages of protein compounds, which serve to form blood, muscle, bone, and milk, and their consequent feeding value, which exceeds that of the grasses, corn fodder, corn stover, or straws. They may be used to supplement these fodders in place of the concentrated nitrogenous feeds, such as bran, cotton seed, linseed, gluten meals, etc. Hay from the legumes is twice or more than twice as rich in protein as that from the grasses.

(2) Their power of gathering large quantities of plant food from natural sources. Many, if not all, of our common legumes acquire considerable quantities of nitrogen from the air. Their roots penetrate deeply into the subsoil, and they thus obtain plant food from depths beyond the reach of plants with smaller root development.

(3) Their manurial value. When the crop is fed most of the nitrogen, phosphoric acid, potash, and other fertilizing ingredients go into the excrement, liquid and solid, and if preserved, make a rich manure. If the crop is plowed under its plant food, including that acquired from the air and gathered from the subsoil, becomes available for succeeding crops. The large amounts of plant food left behind in roots and stubble after the removal of the crop furnish a cheap and valuable store of plant food for following crops.

While the clovers will doubtless prove in the future, as they have in the past, the most valuable of the legumes for general purposes in Connecticut, the cow-pea, soja bean, and vetches are valuable for forage, silage, or hay, and the experiments and observations at the station and elsewhere indicate that they are worthy of careful trial.

Cow-peas.†—Experiments with cow-peas at the South Carolina Station led to the following conclusions:

The cow-pea seems especially adapted to meet the wants of our Southern farmers. Its extensive and deep-root system enables it to withstand the long dry spells common to our climate, and also to gather nourishment from soils on which shallow-growing crops would starve. It responds readily to fertilizers, and on fair soils will produce as large a yield of nutritive matter as almost any forage crop we can grow. It makes such a rapid growth that two crops can be grown in a season. The growth is so luxuriant that all noxious weeds are choked out. The most serious objections urged against this crop are its great bulk and the difficulty of curing it. It is not, however, more difficult to cure than clover, and properly managed, makes an excellent long forage. Chemical analyses of the cow-pea plant in both the green and cured state indicate that (1) for the production of a nitrogenous food, in the shape of a forage crop, the cow-pea vines are almost without a rival; (2) on an acre of ordinary land this crop will probably produce more digestible food than either oats or corn; (3) the manure resulting from feeding this crop is of the highest value, and should be carefully preserved and returned to the land.

---

*Connecticut Storrs Station, Bulletin No. 6, C. D. Woods and C. S. Phelps.
†South Carolina Station, Bulletin No. 8.

*Selection and production of fodder crops.**—As a result of his experience Dr. C. A. Goessmann, director of the Massachusetts State Station, states that the introduction of new crops, especially the legumes, which utilize the nitrogen of the air and soil, and the growth of a greater variety of fodder plants, enable us to meet better the differences in local conditions of climate and of soil, as well as the special wants of different branches of farm industry; and taking this view of the question, the great and valuable family of leguminous plants, such as clovers, vetches, lucern, serradella, peas, beans, lupines, etc., is, in a particular degree, well qualified for that purpose. They deserve also a decided recommendation in the interest of a wider range, for the introduction of economical systems of rotation, under the various conditions of soil, and different requirements of markets. Most of these fodder plants have an extensive root system, and for this reason largely draw their plant food from the lower portion of the soil. The lands are consequently better fitted for the production of shallow-growing crops, as grains, etc. Large productions of fodder crops assist in the economical raising of general farm crops; although the area devoted to cultivation is reduced, the total yield of the land is usually more satisfactory. In a number of instances the station has had good success in bringing up old, worn-out grass land by the use of leguminous forage plants.

THE ACQUISITION OF ATMOSPHERIC NITROGEN BY PLANTS.†

Farmers in all older portions of the country buy large quantities of nitrogen in artificial fertilizers. Nitrate of soda, sulphate of ammonia, dried blood, cotton-seed meal, and fish scraps owe their fertilizing value mainly, and Peruvian guano and tankage largely, to nitrogen, and the same element is one of the chief ingredients of bone manures, ammoniated phosphates, and many other fertilizers. According to an estimate by the Connecticut State Station not less than $500,000 are expended annually for commercial fertilizers in Connecticut. A large amount of this goes for nitrogen, which is one of the dearest of the ingredients of fertilizers and costs at retail from 8 to 18 cents or more a pound. The plants must have this nitrogen or they can not grow. They obtain part of it from the soil and the rest from the air. The nitrogen of the soil has either been accumulated in the past or is supplied in manures. A small quantity in the form of ammonia and other compounds of nitrogen is continually brought to the soil by rain or snow. Late research implies that soils require nitrogen from the air, by the aid of microbes or electricity, or probably both. The nitrogen in the soil is being continually leached away by drainage water, and more or less of it escapes into the air. Soils which are not cultivated, and from which the produce is not removed, accumulate more nitrogen than they lose, so that many virgin soils have a large stock. By ordinary cultivation and cropping the nitrogen is gradually exhausted, unless it is returned by manures or otherwise.

Of the total weight of the air four fifths are nitrogen. This means that over every square inch of the earth's surface there are 12 pounds of nitrogen, and over every acre of land nearly 38,000 tons. Nearly all of the nitrogen of the air is in the form of what is called free nitro-

* Massachusetts State Station, Bulletin No. 36.

† Connecticut Storrs Station, Annual Report for 1889, W. O. Atwater and C. D. Woods.

gen, that is, not combined with any other chemical element. A minute proportion is combined with other elements, in the forms of ammonia, nitric acid, etc. The important question is: Can plants make use of atmospheric nitrogen to any considerable extent? It has been agreed on all hands that the combined nitrogen of the air may be used by the plants; but the quantity is so extremely small as to be of comparatively little consequence. From the practical standpoint it makes very little difference in what form the plants get the nitrogen, provided they can get enough. If there are plants which can be used to gather any considerable amount of nitrogen from the air without cost, the fact is of immense importance, and ought to be clearly understood and rightly applied in practice. Interesting as this problem is to the farmer, it is none the less so to the chemist and vegetable physiologist, and has been the subject of active discussion and experiment for more than fifty years. There are certain kinds of plants, like clover, beans, and others belonging to the family of the legumes which generally get on very well without nitrogenous fertilizers in worn-out soils, and it would seem as though these plants, at any rate, must in some way be able to make use of the nitrogen of the air. But the classic experiments of Boussingault in France, of Lawes and Gilbert in England, and others, have been widely accepted as proving that plants can not use the free nitrogen of the air, and that they get practically very little combined nitrogen from the air, so that they are dependent upon that previously stored in the soil or supplied in manures. Experiments in 1881 and 1882 at Wesleyan University by Professor Atwater, brought the first positive evidence that some plants do acquire large quantities of nitrogen directly from the air. These and later ones by Hellriegel and others in Europe, and those by the Storrs Station have led to the following conclusions:

(1) Peas, alfalfa, serradella, lupine, clover, and apparently leguminous plants in general, are able to acquire large quantities of nitrogen from the air during their period of growth.

(2) There is scarcely room to doubt that the free nitrogen of the air is thus acquired by plants.

(3) That there is a connection between tubercles found on the roots of certain plants and this acquisition of nitrogen is clearly demonstrated. What this connection is, what are the relations of micro-organisms to the root tubercles and the acquisition of nitrogen, and, in general, how the nitrogen is obtained, are questions still to be solved.

(4) The cereals with which experiments have been completed have not manifested this power of acquiring nitrogen, nor do they have such tubercles as are found on the roots of legumes.

(6) As a rule, the greater the abundance of root tubercles in these experiments, the larger and more vigorous were the plants and the greater was the gain of nitrogen from the air.

(7) In a number of these experiments, as in similar ones previously reported, there was a loss of nitrogen instead of gain. The loss occurred where there were no root tubercles; it was especially large with oat plants, and largest where they had the most nitrogen at their disposal in the form of nitrates. As the gain of nitrogen by the legumes helps explain why they act as "renovating crops," the loss in the case of the oats suggests a possible reason why they should appear to be an exhaustive crop.

Practical inferences.—The ability of legumes to gather nitrogen from the air helps to explain the usefulness of clover, alfalfa, peas, beans, vetches, and cow-peas as renovating crops, and enforces the importance of using these crops to restore fertility to exhausted soils. The judicious use of mineral fertilizers (containing phosphoric acid, potash, and lime) will enable the farmer to grow crops of legumes, which after being fed to his stock will, with proper care to collect and preserve all manure, both liquid and solid, enable him to return a "complete fertilizer," in the shape of barn-yard manure, to his land. A further advantage of growing these crops is that the nitrogenous material, protein, which they contain in such great abundance, is especially valuable for fodder.

FEEDING EXPERIMENTS.

*Feeding experiments with steers.**—Feeding experiments carried on at the Texas Station for two seasons, in which ninety-eight steers have been fed on the principal available feeding stuffs of the State, used in different mixtures and amounts, have led to the following conclusions:

(1) Of our different cattle foods, a ration made up of cotton hulls and cotton-seed meal is equal, if not superior, to a ration of any other two feeding stuffs used for fattening cattle, but a cheaper ration may be compounded of silage and cotton seed, or of corn, hay, and cotton seed, at the prices given.

(2) The addition of some other feeding stuff to the cotton hull and cotton-seed meal ration makes it more palatable to cattle, and produces better results in gain in weight. Corn meal, hay, silage, and molasses, each one added to cotton hulls and cotton-seed meal, made larger gains than hulls and meal alone, in the order named, molasses giving the best result.

(3) Of the several rations containing silage, silage with cotton hulls, and cotton-seed meal gave the best gains; silage with cotton-seed meal came second; silage with boiled cotton seed third; silage with corn-and-cob meal, and cotton-seed meal fourth; silage with corn-and-cob meal fifth. Dry corn fodder did not give as large gain as silage. Molasses did not improve the ration containing silage.

(4) Cotton hulls and cotton-seed meal, with hay, corn, silage, and molasses, gave larger gains than silage and cotton-seed meal, or silage and cotton seed.

(5) Cotton-seed meal, with other feeding stuffs and fodders, gave larger gains than cotton seed with other feeding stuffs and fodders.

(6) Cotton seed, with other feeding stuffs and fodders, made gains at less cost for food than cotton-seed meal with other feeding stuffs and fodders.

(7) After feeding any of the rations used without change for sixty days, the daily gain diminished, until finally, in some pens, it ceased entirely; but with a change of ration, the daily gain in all of the pens was largely increased, in some pens exceeding the average of the first period of feeding.

(8) Corn and hay alone are more costly, and will not fatten cattle as rapidly as rations containing cotton seed and cotton-seed meal with cotton hulls or silage; and boiled cotton seed added to the corn and hay ration makes more rapid gain than corn and hay alone, and at considerable less cost per pound for food consumed.

(9) The waste from cattle fed hay, corn, silage, and raw cotton seed was worth considerable more for hogs running after the steers than the waste from cattle fed silage, cotton hulls, and cotton-seed meal.

Feeding experiments with pigs.†—Feeding experiments with twelve pigs, carried on at various times during nearly eighteen months at the Maine Station, indicate that the profits of feeding swine may depend in part upon the way in which feeds are combined and not follow the market values. In six feeding periods where the rations compared contained practically the same digestible material, 2,643 pounds of digestible feed in one combination produced 890 pounds of growth while 2,651 pounds of digestible food in another combination with less of nitrogenous material produced only 617 pounds. In other words, it took nearly one half more feed to produce a pound of growth with one set of rations than with the other. A certain proportion of nitrogenous feeds, like skim-milk, pea meal, and gluten meal increased the efficiency of the ration in a marked manner. The advantage of a nitrogenous feed in the ration seems to pertain to the fattening period as well as to the period of growth. A mixture of pea meal and corn meal or of gluten meal and corn meal proved to be much more efficient than corn meal alone in feeding animals already well grown and quite fat. When we consider that over 70 per cent of the weight added to the body of a fattening hog is fat, while only 6.5 per cent is lean meat the favorable influence (at least indicated) of a liberal supply of protein upon fat production is very apparent. No marked

* Texas Station, Bulletin No. 10, F. A. Gulley and J. W. Carson.

† Maine Station, Annual Report, 1889, p. 85

effect was noted upon growth by a wide variation in the amount of drink given the different animals. Pigs weighing about 109 pounds took approximately 7 quarts of water daily and made but slightly less gain than animals of the same size drinking only half as much. When unskimmed milk was substituted for part of a ration with corn meal, without changing the amount of dry matter fed, the efficiency of the ration was greatly increased. A still further substitution of milk for meal appeared not to increase the rate of growth. For instance, a ration, one third of the nutrients of which were furnished by skim-milk, in a single trial proved to be worth practically as much as a ration two thirds of the nutrients of which came from skim-milk. In the latter case the milk simply replaced corn meal in the ratio of 8 pounds of milk to 1 pound of meal, which is almost the exact ratio of equal quantities of digestible material.

*Skim-milk as food for pigs.**—The raising of pigs for the profitable utilization of skim-milk is an important auxiliary of dairying, which is the leading branch of farming in Vermont. Investigations at the Vermont Station having indicated that the methods of feeding employed by the best farmers involve a great waste of food materials, the station undertook experiments with special reference to economy in feeding. These were made with two pigs each of the three breeds, Berkshire, Chester White, and Yorkshire, which were fed from May 14 to November 11, 1889, on skim-milk, corn meal, and wheat bran, the rations being varied for each of four periods. The pigs sold for 5¼ cents per pound dressed weight (a lower price than the average), and shrank 18 per cent in dressing, making the selling price equal to 4.32 cents per pound live weight. The gross cost of the food consumed per pound of increase in live weight was 3.33 cents, and the value of the fertilizing ingredients in the food was 2.08 cents, making the net cost of the pork per pound, live weight, 1.25 cents. The value of the food consumed for each pound of increase in dressed weight was 4.06 cents, and the fertilizing value of this food 2.54 cents, leaving the net cost of a pound of dressed pork 1.52 cents. Since the pork sold for 5.25 cents a pound there was, on this basis, a net gain of 3.72 cents per pound. "If we suppose the manure to offset the care, and subtract from the amount received for the pork the amount paid for the grain fed, the remainder may be considered the amount realized for the skim-milk." The amount realized from 100 pounds of skim-milk averaged 24 cents.

Among the conclusions are the following:

(1) Pig feeding is profitable (in Vermont) even at the low price of 5¼ cents per pound dressed weight, provided the pig is sold at an early age, *i. e.* by the time it reaches a live weight of 180 pounds, or soon after.

(2) Grain can be fed to young pigs with profit; in feeding it to pigs weighing over 200 pounds there is a loss.

(3) Young pigs should be fed a ration in which the flesh-producing material is more prominent than the heat or fat-producing.

(4) The old saying, "Grow the pig and then fat him," should be changed to "Grow the pig and then sell him."

(5) This system of feeding and selling makes it possible to raise two sets of pigs in twelve months.

(6) The fertilizing value of the manure from the food consumed by the pig is in Vermont equal to nearly one half the value of the pork, and constitutes the largest gain from the feeding.

(7) In these trials the three breeds, Berkshire, Chester White, and Yorkshire showed but little difference, whatever difference there was being in favor of the Chester White.

* Vermont Station, Bulletin No. 18, W. W. Cooke.

In brief, the two points especially brought out in this experiment are, the value of skim-milk as food for pigs, and the fact that the largest profit is from the young animals. These results coincide essentially with those of many others made elsewhere. There is another important matter in this connection which is generally overlooked. In making pork, dairy farmers have the great advantage that skim-milk is a largely nitrogenous food. A large part of the pork produced in the United States is grown on corn, and in consequence is excessively fat. With nitrogenous food swine have better developed organs and their flesh is leaner. Lean pork is more valuable for nourishment and commands better prices. For further suggestions in this line, see Report of the Office of Experiment Stations in the Report of the Secretary of Agriculture, 1889, pp. 515-519.

*Feeding bone meal and hard-wood ashes to pigs living on corn.**—The Wisconsin Station has made three experiments in which the effects of feeding corn meal alone were compared with those where small amounts of either bone meal or wood ashes were fed with the corn meal. The animals were slaughtered at the close of the trial and the strength of the thigh bones tested. These bones were then burned to determine the amount of ash they contained. The conclusions drawn from these experiments were as follows:

(1) That the effect of the bone meal and ashes was to save about 130 pounds of corn, or 28 per cent of the total amount fed in producing 100 pounds of gain, live weight.

(2) That by feeding the bone meal we doubled the strength of the thigh bones; ashes nearly doubled the strength of the bones.

(3) There was about 50 per cent more ash in the bones of the hogs receiving bone meal and hard-wood ashes than in the others.

A careful examination revealed no difference in the proportion of lean to fat meat in the several carcasses. * * * The bone meal and ashes seemed to have no effect on the size or weight of any of the internal organs or the weight of blood. The effect is evident only in the building up and strengthening of the bones and aiding digestion. These experiments point to the great value of hard-wood ashes for hog feeding, and show that they should be regularly fed. Bone meal seems to build up somewhat stronger bones than ashes, but ashes do the work well enough and usually cost nothing with the farmer. Where they can not be obtained bone meal is strongly recommended.

SIMPLE METHODS FOR TESTING MILK.†

Farmers and dairymen have long known of the wide difference in the value of the milk of different cows for butter making. They are finding out that it is not always that cow of their herd which gives the largest quantity of milk that is worth the most for this purpose, and that cows which ordinarily pass for good cows may differ very widely in the amount of butter they produce. Many already understand also that the cost of keeping is not proportionate to the quality of the milk produced, *i. e.* that the cost of feed for the production of 1 pound of butter fat is a factor which varies widely with individual cows. Breeders are coming to appreciate the importance of judging of cows by the amount of butter fat in their milk. Creameries and patrons furnishing milk to creameries are learning that the paying for milk according to the quantity furnished is unjust, and that not the quantity of milk but the amount of butter fat which it contains should be the basis for payment.

The result is that a demand has grown up for a simple, quick,

* Wisconsin Station, Bulletin No. 25, W. A. Henry.

† This article was prepared by E. W. Allen, Ph. D., of this Office.

inexpensive, and sufficiently accurate test of the amount of fat in milk. The agricultural experiment stations realizing the importance of this subject, have within the past two or three years given considerable attention to it, and the result has been the devising and testing of several simple methods. These are another interesting application of the scientific principles of the laboratory to agricultural practice, for they place within the reach of the farmer and the breeder the means for finding out the value of each cow of his herd for dairy purposes, and of the creamery for testing the milk delivered by each patron, and that, too, with very little practice, little time, and no considerable expense.

There are several evils which the use of these tests will help to remedy. The first is the keeping of unprofitable cows in a herd. Nearly every farmer who has roughly studied his cows by the only means he has usually had, the yield of the churn, realizes that while some are profitable, others are much less so. As a matter of fact, many are really kept at a loss, and these latter naturally eat up part of the profits from the better animals. An illustration of the differences in cows, even in carefully bred herds, is furnished by the record given in Bulletin No. 9 of the Illinois Station, of tests of a herd of sixty-four cows which "had been selected and bred with more than average intelligence." The author says: "The average per cent of fat found was 4.21; the highest, 5.85; the lowest, 2.75—a variation of 3.10 per cent. The average of ten cows was 5.41; of ten others, 3.2. Dividing the herd into four equal lots, the average of one lot of sixteen was 5.18; of another lot of same number, 3.38." In another trial* the milk of thirty-eight cows, including three herds, was tested, and the total amount of butter fat contained in a single milking of each cow calculated. "If we compare Nos. 2, 3, 22, and 8 (the time since calving being in each case two hundred and forty days), we find that No. 2 produced twice as much butter fat as No. 3, and nearly five and one half times as much butter fat as No. 8, and that No. 22 produced seven and one half times as much butter fat as No. 8. Comparing No. 13 with No. 14 shows that nearly twice as much milk must be handled by the owner to get the same weight of butter fat from No. 14 as from No. 13. Besides these extreme cases mentioned, cows can be found all along the line from very profitable to very unprofitable."

To weed out these less profitable or unprofitable animals from a herd, and to make sure that every animal kept is qualified in a high and profitable degree to convert the hay and fodder articles of the farm into butter fat, is an important matter and one upon which success in dairying largely depends.

To gauge cows by the quantity of milk they give and the length of time a good yield is maintained is not sufficient if the milk is to be used for butter making. To know the amount of butter fat produced by an animal daily or weekly, not only the weight of the milk given but also the proportion of fat contained in the milk must be known. The two go hand in hand, and an estimate of a cow for butter making based on either one alone is not altogether correct, for a cow giving a relatively small quantity of milk rich in fat may yield a larger total amount of butter fat per day than one giving twice as large a quantity of milk poor in fat, and the reverse.

Another evil is a bad tendency in breeding, which is encouraged

* Illinois Station, Bulletin No. 10.

by the paying for milk according to quantity simply without regard to quality. In a late bulletin of the Vermont Station* Director Cooke refers to this in the following words:

A careful study of the herds of this State will show the evil effects of the present method of paying for milk. Wherever in this State a cheese factory has been run for many years it will be found that the herds in that vicinity all give thin milk and will produce but a small number of pounds of butter in a year. The reason of this is evident. The patrons have been paid entirely by the weight of their milk, and so all their efforts in breeding have been directed to getting cows that would give the largest quantity of milk without regard to its quality, and as a large flow of milk is almost always accompanied with a poor quality of milk, the natural result is that the general character of the milk of the neighborhood is lowered. But the evil goes further than this. Cows that give this large flow of milk that is watery usually dry up quickly, and there will be found all through this State in the vicinity of cheese factories herds of cows of large form and large udders, which are large consumers of food, give a large flow of thin milk during May and June, and are pretty well dried up by October, so that the total amount of milk produced per cow per year is less than 3,000 pounds, and the total butter which this milk will make is scarcely more than 100 pounds. On the contrary, the best herds in the State will be found where the product of the herd has been used at home in making butter, and the breeding has been with the view of getting the cow that would make the most butter per year on moderate food.

The third evil affects both the creamery and the farmer. Valuations based on quality, so largely used in other directions, are beginning to find application in the case of dairy products, and nowhere is the desirability of such valuation more felt. The importance of this matter to creameries where the milk of a large number of patrons is all paid for alike, according to its weight or measure, has already been felt, and attention has been called to it by several stations.

In Bulletin No. 9 of the Iowa Station Professor Patrick says:

The pooling system of purchasing milk, now universally practiced at separator creameries, is defensible only on grounds of expediency, as a makeshift to be endured only until a better system shall be developed. It makes no pretense to justice in its treatment of the individual patron; it places a premium on quantity rather than, and even at expense of, quality; it drives patrons possessing rich-milk dairy herds and those who feed liberally and intelligently, into private dairying; it tempts the short-sighted and cunning into dishonest practices, and tends in every way to demoralize the creamery industry.

The creamery proprietor is not, however, the chief sufferer. He can always save himself, and continue to profit by lowering the price of milk to correspond with the average quality of all received, as shown in the butter product. But the farmer who, producing milk of superior quality from a herd which has cost much time and money to bring together, is obliged to pool with those producing inferior milk from scrub herds and poor feed—not to mention the possibility of home skimming or watering—he, by long odds, is the greatest sufferer.

The following examples illustrate the wide differences in milk supplied by different patrons:

The Illinois Station† tested the milk brought to three large creameries in the State by one hundred and eighty-four patrons. This milk was found to vary all the way from 2.8 to 4.75 per cent in butter fat. If the milk containing 2.8 per cent of fat is paid for at the rate of 50 cents per 100 pounds, then the richer milk would be worth, on that basis, 84.8 cents per 100 pounds. The Vermont Station† tested the milk delivered by twenty-seven patrons to a creamery in that State and found it to vary from 3.35 to 4.91 per cent in fat. This creamery was at the time paying 60 cents per 100 pounds for all the milk it

* Vermont Station, Bulletin No. 21.

† Illinois Station, Bulletin No. 9.

received. Valued according to its quality at this rate, the poorest milk, with 3.35 per cent of fat, would be worth 52 cents, and the richest, with 4.91 per cent, 74 cents per hundred, a difference of 22 cents on every 100 pounds. As 270 pounds of the richer milk were brought in one day, this difference would make a considerable amount in the course of a year to the patron who furnished it. These are not uncommon cases picked out to serve a purpose, but similar tests at various other stations have shown equally striking variations. Obviously a system so unfair ought to be improved.

The churn test, which until recently has been the farmers' main dependence, requires too much time and labor to be commonly and rigidly applied. The ordinary methods of the chemical laboratory require too complex and costly apparatus and skillful manipulation to be adapted to the use of farmers or creameries.

Simple methods depending on the specific gravity (lactometer) or on the thickness of the cream layer in cream tubes, do not furnish satisfactory indication of the actual amount of fat. All methods dependent upon the color or transparency of the milk are likewise unreliable. The transparency of milk is affected by the size of the fat globules, so that samples of milk containing like percentages of fat may be unequally transparent.

The lactocrite, an apparatus by which the fat of a given quantity of milk, after having been set free by a mixture of sulphuric and acetic acids, is separated and collected by centrifugal force, is an expensive piece of apparatus and the method has not made its way into general use.

The "oil test," which is practically a churn test on a small scale, has been found* by actual comparison with a large churn to differ, with the same cream, by 3 to 4 per cent of butter fat, not all the material separated by the method being actually fat.

Numerous other methods, which from time to time have been proposed, have, because they were either too complicated, expensive, or insufficiently accurate, not seemed to answer the demand, or at least have not found general application.

No less than seven different methods, all quick and fairly reliable, but differing somewhat as to simplicity of apparatus and manipulation, have lately been devised and are being subjected to very rigid trials at the stations, both by experienced chemists and by farmers, dairymen, and others unaccustomed to chemical work. These simple methods all depend upon the same general principle. The casein, albumen, fibrin, etc. ("curd"), of the milk surround the minute fat globules and hinder their rising as cream and aggregating to make butter. By treating the milk with acids or alkali this curd is more or less acted upon or dissolved, thus diminishing the hinderance to the rising of the fat globules. These collect at the top of the solution in a layer, the thickness of which can be readily measured. This separation of the fat from the dissolved curd is aided by either collecting the fat in gasoline or ether, which is afterwards evaporated, or by adding hot water, or by centrifugal motion.

The Short method,† one of the first of these quick methods to make its appearance, is the only one in which the nature of the fat is changed. It depends upon the fact that when milk and a solution of strong alkali (caustic potash and soda) are heated together at the temperature of boiling water for a sufficient time the alkali and the

* Wisconsin Station, Bulletin No. 12.
† Wisconsin Station, Report for 1888, p. 124.

fat of the milk unite to form a soap, as occurs in ordinary soap manufacture where fats and grease are heated with alkali (potash or soda). This soap is dissolved in the hot liquid. The casein and albumen are changed by the alkali and become much more easily soluble. If an acid is now added (a mixture of acetic and sulphuric acids being used in this method) the alkali of the soap is taken away by the acid, leaving the fat free. The casein, albumen, etc., are first precipitated and then dissolved by the acid. There is then nothing left in the milk to prevent the fat from following the law of gravity and rising and collecting in a narrow tube at the top of the liquid, where it may be measured by a graduated scale like that of a thermometer. The percentage of fat indicated by this reading is found by reference to a table. The author states that this method does not give accurate results where less than 0.5 per cent of fat is present, unfitting it for the testing of skim and buttermilks low in fat. In one hundred and forty-six comparisons made by different stations, of this method and the gravimetric methods ordinarily used by chemists, twenty-one showed differences of 0.2 per cent or more from the gravimetric, this difference being very rarely more than 0.3 per cent. Of six samples of skim-milk tested four differed by 0.2 to 0.22 per cent. The time required for a single analysis is approximately three and a half hours, although several analyses may be made at the same time.

*Parsons method.**—The measured milk, according to this method, is shaken with alkali (soda solution), alcoholic soap solution, and gasoline. The gasoline under these conditions dissolves the fat and rises with it to the surface. A part of this solution of fat in gasoline is measured out, the gasoline evaporated, a few drops of strong acetic acid added, the fat dried in an oven, and what remains behind measured in a narrow, graduated tube. From this measurement the percentage of fat in the milk can be quickly calculated by means of a table. The time required for the analysis is about two and a half hours, but several analyses may be made at the same time. Of ninety-three trials made with whole milk six differed from the gravimetric determination by 0.2 per cent or over; of seventeen tests of cream, five differed by 0.2 per cent or over, the greatest error being 0.52 per cent; and of thirteen tests of skim-milk the error was in no case as large as 0.15 per cent. The cost of the necessary apparatus is from $5 to $10, depending upon the number of duplicates to be made at once.

Failyer and Willard method.†—The casein, albumen, etc., are dissolved by heating the milk with strong hydrochloric acid, the fat is dissolved and collected at the surface by gasoline, and the gasoline is evaporated by gentle heat, leaving the fat free. Hot water is now added, which brings the fat up into the narrow graduated neck of the tube where it can be read off.

The time required is about half an hour for a single sample, or an hour and a quarter for four samples. In five out of twenty-two trials made there was a difference of 0.2 per cent or over from the gravimetric analyses.

Patrick method; Iowa Station milk test.‡—The curd (albumen, casein, etc.) of the milk is dissolved by boiling the milk with a mix-

* New Hampshire Station, Report for 1888, p. 69; New York State Station, Bulletin No. 19 (new series).

† Kansas Station, Report for 1888, p. 149.

‡ Iowa Station, Bulletins Nos. 8 and 11.

ture of sulphuric and hydrochloric acids and sulphate of soda, the last being used to prevent the formation of a scum of undissolved materials which holds the fat. The acid mixture, as recently modified, contains rectified methyl alcohol. The liquid is then cooled, the fat rises to the surface, is heated again to clarify it, a part of the acid solution is drawn off through a small hole in the body of the tube ordinarily closed by a rubber ring, and the column of fat is read off on the scale. The time required is about twenty minutes for a single test, or six may be made in one and a half hours. The cost of chemicals is not more than 1 cent for each analysis. In thirty-five trials of this method the results of only three differed by 0.2 per cent from the results obtained by the gravimetric (laboratory) method; and in thirteen tests of skim-milk, only one test differed by 0.2. The method has not given good success with samples of buttermilk.

*Cochran method.**—The chemicals used in this method to dissolve the casein, etc., are sulphuric and acetic acids, which are heated with the milk about six minutes. After cooling ether is added, which dissolves out the fat and brings it to the surface. The ether is evaporated by gentle heat, and the liquid poured into a narrow measuring tube, where, after the addition of hot water, the fat collects in a clear layer and is read off. A table gives the per cent of fat corresponding to the reading of the tube.

In ten trials out of fifty-nine made by this method the results differed by 0.2 per cent of fat or over from the results by chemical analysis. In nine analyses of skim-milk this difference was in only one case as high as 0.15 per cent; in six tests of buttermilk the greatest difference was 0.27, all others being under 0.15 per cent.

The method is covered by a patent. It is not a station method but has been tested by several stations. The cost of apparatus and the right to use the method varies from $10 for the dairyman's outfit sufficient for testing four samples at a time, to $50 for the large creamery outfit for making sixty tests at one time. The cost of chemicals is about one half cent per analysis, and the time required one half hour for a single test, or one and a half hours for twenty-four tests.

Babcock method.†—In this method the curd is dissolved by sulphuric acid, no heat being applied. The separation of the fat is then aided by a simple centrifugal apparatus, consisting of a wheel fitted with pockets and surrounded by a tank filled with hot water (about 200° F.). The bottles containing the liquid are placed in an inclined position within the pockets of the wheel with the mouths toward the axis, and whirled rapidly for several minutes. The acid and the dissolved curd and water of the milk being much heavier than the fat, are thrown outward (to the bottom of the bottle) by the rapid motion and the fat collects near the neck. The separation of the fat is rapid and very complete. Hot water is now added to bring the fat up into the graduated neck, and the bottles are whirled for a few minutes more to clarify it. The reading of the column of fat gives the per cent directly. No complicated or expensive centrifugal machine is necessary, any arrangement by which a horizontal wheel, surrounded by a tank for the hot water and fitted with

* Journal Analytical Chemistry, Vol. III, p. 381; also New York Cornell Station, Bulletin No. 17, and Pennsylvania Station, Bulletin No. 12.

† Wisconsin Station, Bulletin No. 24.

pockets for the bottles, may be made to revolve at the rate of from seven to eight hundred revolutions per minute, answering the purpose.

The method is applicable with buttermilk, skim-milk, cheese, and cream. Out of thirty tests the results of only one showed a difference as large as 0.2 per cent from the results by chemical analysis. Out of four tests of cream the largest difference was 0.3 per cent; two tests of skim-milk were both within 0.8 per cent of the gravimetric; and the largest error in three tests of buttermilk was 0.23 per cent. Tests have also been made with whey, condensed milk, and cheese. In one test out of four which were made with cheese, the error was as high as 0.4 per cent of fat.

"Two samples of milk may be tested in duplicate in fifteen minutes, including all the work, from the mixing of samples to the cleaning of the bottles. After the milk has been measured sixty tests may be made in less than two hours, including the cleaning of the bottles." The cost of acid for the test should not exceed one half cent per test. With properly made bottles the breakage is very slight.

*Vermont Station test.**—This test, which is similar to the one devised by Dr. Babcock, depends on dissolving the curd by treating the milk with a mixture of hydrochloric acid and amyl alcohol and with concentrated sulphuric acid, without the application of heat, and whirling the bottles containing the liquid in an improved centrifuge for from one half to one minute. This is said to be sufficient to cause the fat to collect in the narrow neck of the bottle where it is read off, the reading indicating the per cent of fat in the milk taken. No hot-water jacket around the separator or hot water in the bottles is used. The time required for a single test is not more than five minutes, and twenty-five samples can be tested in an hour.

In the case of twenty-four samples which were tested by an inexperienced person, 75 per cent of the results were within 0.1 per cent of the chemical analyses, and in no case was the error as large as 0.3 per cent. Professor Cooke says: "If the sample has been correctly taken, and the column of fat in the tube is correctly read, there is no chance for the results to be wrong." Skim and buttermilks containing less than 1 per cent of fat can not be accurately tested by this method. The cost of chemicals is not more than one fifth cent per test. The machine is patented and costs, including bottles, from $20 to $50, according to the size, the one suggested for creameries carrying six bottles and costing $25.

"The method of analysis is so easy and cheap that it would be a very simple matter for each patron of the creamery or cheese factory to bring to the factory samples of milk of his individual cows and learn which were good cows and which ones should be discarded. In this way a single machine at a central point would be sufficient to test the milk of several hundred cows. Any one can see at once what an immense stride Vermont dairying would make under these conditions."*

Several of the stations offer to teach those wishing to learn the use of these simple tests, or to test the accuracy of the graduated tubes used for measuring the separated fat. As all the methods depend for their accuracy quite largely on the correctness of this measurement, the correct gradation of the apparatus is of vital importance.

* Vermont Station, Bulletin No. 21.

Considerable trouble has been experienced in securing apparatus for some of the methods made with proper care in this respect.

The providing, in these ways, of reliable means for testing a large number of samples of milk in a short time has led to the proposal, and in several cases the adoption at creameries, of the so-called "relative value plan." This consists in paying for the milk of each patron according to its quality, as well as quantity, by allowing so many cents for every pound of butter fat delivered in the milk, as indicated by one of these rapid methods. It is claimed that this system is sure, sooner or later, to supplant the present irrational one, the greatest hinderance to its general adoption being the large amount of work it is supposed to involve. This, however, is not so great as would at first seem. Three plans have been proposed for the sampling. One, where a sample is taken from each patron's milk as it is delivered at the creamery, to be tested by itself and recorded with the weight of milk. Another, advocated by Professor Patrick, of the Iowa Station,* in which a sample proportional in size to the amount of milk brought, is taken each day when the milk is delivered, the daily samples of each patron's milk being kept together by themselves for from seven to ten days, and then the average quality of the patron's milk for that time ascertained by a single test. Some preservative is added to the milk to prevent its spoiling. According to Professor Patrick's experiments, corrosive sublimate, although open to serious objections, being a violent poison, gives the best results of any agent yet found. Some magenta or aniline color is to be added to each sample containing corrosive sublimate to prevent accidental poisoning. The third plan advocated by Professor Cooke, of the Vermont Station,† is the taking of samples of each patron's milk by means of a sampling tube, which he describes, about three times a week, preserving the milk by means of corrosive sublimate, and analyzing the composite sample at the end of the week.

Tables indicating the prices to be paid for milk with different percentages of fat have been worked out, and have been printed with directions for their use in the bulletins of several stations.‡

These tests are being subjected to the test of practical experience as well as of the laboratory, and, doubtless, improvements will be suggested. There is every reason to expect that great benefit will result to the farmer, the breeder, and to the dairy interest in general from their use.

THE AGRICULTURAL COLLEGES AND THE EXPERIMENT STATIONS.

By the terms of the act of Congress of March 2, 1887, under which nearly all the stations are organized, they are departments of the colleges receiving the benefits of the land grant made to the States under the act of Congress of July 2, 1862. As a rule the colleges have welcomed the establishment of the stations and have carried out the spirit of the acts of Congress by aiding the stations with land, buildings, libraries, apparatus, and other facilities for the successful

* Iowa Station, Bulletin No. 9.

† Vermont Station, Bulletin No. 21.

‡ Vermont Station, Bulletin No. 16; New York State Station, Bulletin No. 19 (new series); Pennsylvania Station, Bulletin No. 12.

conduct of their investigations. The inauguration of original research in agriculture on so extended and useful a scale at the land grant institutions, has undoubtedly done much to attract renewed attention to their agricultural features and to increase the demand for their strengthening and enlargement in the direction of such instruction as will tend to provide their graduates with a suitable equipment for the practical duties of the farm, as well as of the laboratory or the shop. There has been impatience with what have appeared to be failures on the part of some of these institutions to meet the demand for technical training in agriculture. In one or two instances this has resulted in the removal of the agricultural departments from the colleges to which the land grant funds were originally given, and the establishment of new agricultural colleges on separate foundations. In the majority of cases it has been deemed best to follow the modern tendency to group instruction in numerous and varied branches of knowledge in large institutions comprising more or less closely associated colleges or departments.

Public attention is now strongly attracted to the land grant colleges because of the passage of an act at the last session of Congress making grants of public funds for the maintenance and endowment of these institutions. The chief provisions of this act are as follows: Annual appropriations are to be made out of the proceeds of sales of public lands, to each State and Territory, for the more complete endowment and maintenance of the colleges for the benefit of agriculture and mechanic arts established in accordance with the act of Congress, July 2, 1862. Fifteen thousand dollars are appropriated for the year ending June 30, 1890, and there is to be an annual increase of $1,000 in the amount of the appropriation thereafter for ten years, after which time the annual amount to be paid to each State and Territory is to be $25,000. These funds are to be applied only to instruction in agriculture, the mechanic arts, the English language, and the various branches of mathematical, physical, natural, and economic science, with special reference to their applications in the industries of life, and to the facilities for such instruction. It is also stipulated that no money shall be paid under this act to any State or Territory for the support and maintenance of a college where a distinction of race or color is made in the admission of students. But the establishment and maintenance of such colleges separately for white and colored students shall be held to be in compliance with this act if the funds received under the act are equitably divided between the two races. Payments of appropriations from the United States Treasury are to be made on the warrant of the Secretary of the Interior, and detailed reports of the amounts so received and of their disbursement are required to be made to the Secretary of Agriculture and to the Secretary of the Interior on or before the first day of September of each year. No portion of these funds can be applied to the purchase, erection, preservation, or repair of any building or buildings. In case these funds are in any way diminished, lost, or misapplied in any State or Territory the loss must be made good by the State or Territory before it can receive further appropriations under this act.

An annual report regarding the condition and progress of the college must be made by the president of each of the colleges receiving the benefits of the act to the Secretary of Agriculture and to the Secretary of the Interior. This report must include statistical information relating to receipts and expenditures, libraries, number of

students and professors, and also as to any improvements and experiments made under the direction of any experiment station attached to the college with the cost and results, and such other industrial and economical statistics as may be regarded as useful. If for any reason the Secretary of the Interior shall refuse to certify that any State or Territory is entitled to receive its share of the annual appropriation under this act the facts and reasons for this refusal must be reported to the President in order that the State or Territory may have an opportunity to appeal to Congress from his decision. The Secretary of the Interior is charged with the proper administration of the law and is required to report to Congress the disbursements made under this act and whether the appropriation of any State or Territory has been withheld and, if so, the reasons therefor.

There is every reason to believe that the stations as well as the colleges will be greatly benefited by the provisions of this act, for many of the institutions which from lack of funds, have not had properly equipped agricultural departments, will now be able to supply themselves with more adequate facilities for instruction and research in these lines, and will be able hereafter to extend much more efficient aid to the stations than they have hitherto been able to give. It is to be expected also that the increased endowment will bring increased numbers of students to these departments and that the instruction given will be more thorough. The result will be that we shall have more young men prepared for efficient service as investigators in the stations and on the farms where co-operative experiments are carried on under the supervision of the stations.

The experience of thirty years as well as the advancement in agricultural science during that period has taught us much concerning what should be included in courses of study for agricultural colleges. The farmers themselves are also very much more alive to their needs in technical education; it is to be expected, therefore, that the funds granted under this act will be economically expended to help to make larger numbers of our youths intelligent farmers and to raise the general plane of agricultural practice in this country.

AGRICULTURAL COLLEGES RECENTLY ORGANIZED.

A list of the agricultural colleges in the United States, with locations and names of chief officers, will be found on pages 548–550. The following brief statements relate to colleges recently organized:

College of Agriculture of the University of Arizona.—The University of Arizona was established by an act of the legislature of the Territory passed during the session of 1888–89. It is located near Tucson, and the schools of agriculture and mines will be opened for students in January, 1891. Other departments of the university will be organized as soon as practicable. The faculty thus far appointed are Merrill P. Freeman, chancellor; F. A. Gulley, M. S., professor of agriculture and director of the experiment station; C. B. Collingwood, B. S., professor of chemistry in the School of Agriculture.

Agricultural College of New Mexico.—This institution was established by an act of the legislature of the Territory during the session of 1888-89. It is located at Las Cruces, Doña Aña County, and its president is Hiram Hadley, M. A., who is also professor of mathematics. The other members of its faculty are: Ainsworth E. Blount, M. A., professor of horticulture and agriculture; Elmer O.

Wooton, B. S., professor of botany and chemistry; John P. Owen, professor of history and civics and principal of preparatory department; Phoebe Haines, M. S., teacher of drawing; Ida Jones, teacher of elementary classes, and Cosette Rynerson, teacher of instrumental music.

The college owns a fine tract of land, about 40 acres of which have been put into excellent condition and are being planted in an experimental orchard, vineyard, and field crops.

A two-story and basement brick building is nearing completion, and apparatus for the departments of chemistry, physics, botany, and mathematics has been purchased. Reference and general libraries have been begun. Eighty-five students are in attendance this year, about twenty of whom are in the college classes. The prospects for rapid growth are good.

The North Carolina College of Agriculture and Mechanic Arts.—This institution was established in accordance with an act of the legislature of North Carolina passed March 7, 1887. It is located at Raleigh, and its president is Alexander Q. Holladay. The other members of its faculty are: Joseph R. Chamberlin, B. S., professor of agriculture, live stock, and dairying; W. F. Massey, C. E., professor of horticulture, arboriculture, and botany; W. A. Withers, M. A., professor of general and agricultural chemistry; D. H. Hill, M. A., professor of English and book-keeping; J. H. Kinealy, D. E., professor of practical mechanics and mathematics; W. E. Weatherly, assistant instructor in practical mechanics; F. E. Emery, assistant professor of agriculture; B. S. Skinner, superintendent of farms and gardens.

The college was opened for students October 3, 1889, and the number of students in attendance this year is about one hundred. Two courses of study of four years each are offered, the agricultural course leading to the degree of Bachelor of Science in Agriculture, and the mechanical course leading to the degree of Bachelor of Engineering. The college has two buildings and an income of $7,500 from the land-grant fund of 1862. It also expects to receive a share of the appropriations made under the recent act of Congress. It has heretofore had the proceeds of a State license tax on fertilizers, amounting to $20,000 per annum, but as this tax has recently been declared by the courts to be unconstitutional this source of revenue has been cut off.

North Dakota Agricultural College.—This institution is located at Fargo and its president is H. E. Stockbridge, Ph. D. The other members of its faculty are H. L. Bolley, M. S., professor of botany, and E. F. Ladd, professor of chemistry.

Rhode Island State Agricultural School.—This institution was organized by an act of the legislature of Rhode Island, passed March 23, 1888. It is located at Kingston and its president is John H. Washburn, Ph. D., who is also professor of chemistry, dairying, and science of government. The other members of its faculty are: Charles O. Flagg, B. S., professor of agriculture and stock breeding; L. F. Kinney, B. S., professor of horticulture; Homer J. Wheeler, Ph. D., professor of geology; Samuel Cushman, lecturer on bee culture; F. E. Rice, M. D., M. R. C. V. S., professor of veterinary science, physiology, and zoology; Serena Stockbridge, instructor in French, English, and Latin; M. T. Rodman, superintendent of shops and instructor in woodwork. The buildings already erected are a laboratory, dormitory, boarding-house, veterinary hospital, and barns. The institution

was opened for students September 23, 1890. The first class consists of twenty-six men and four women.

Clemson Agricultural College.—This institution was established by an act of the legislature of South Carolina passed March, 1889. It is located at Fort Hill, the former residence of John C. Calhoun, and its post-office address is Pendleton. H. A. Strode is president of the college and director of the experiment station connected with it.

Agricultural College of Utah.—This institution was established by an act of the legislature of the Territory passed March 8, 1888. It is located at Logan, and its president is J. W. Sanborn, B. S., who is also professor of agriculture. The other members of its faculty are Evert S. Richman, B. S., professor of horticulture and botany; William P. Cutter, B. S., professor of chemistry; Abbie L. Marlatt, B. S., professor of domestic economy; John T. Caine, jr., professor in the preparatory department; Alonzo A. Mills, B. S., farm superintendent. The buildings include a college building, experiment station building, horticultural building, boarding-house, farm-house, two cottages, and farm and station barn. The college farm has been planted with experimental crops. The college was opened to students September 4, 1890, and seventy-six students are now in attendance. Industrial courses in agriculture, mechanic arts, civil engineering, and domestic arts have been established. A business course is also contemplated.

THE ASSOCIATION OF AMERICAN AGRICULTURAL COLLEGES AND EXPERIMENT STATIONS.

The Association of American Agricultural Colleges and Experiment Stations held its fourth annual convention November 11–13, at Champaign, Illinois, with the University of Illinois. The Association is made up of representatives of the land grant colleges and experiment stations and of the United States Department of Agriculture.

The meeting was the largest the Association has yet held. There were one hundred and ten delegates, representing thirty-nine States and Territories, and about seventy colleges and stations. It was noticeable and the cause of frequent congratulation that this convention contained an unusually large number of the experiment station workers in addition to the directors. President Smart, of the Purdue University of Indiana, presided at the general sessions. As a full report of the proceedings will be published as a separate bulletin of the Office of Experiment Stations, only general references to the action of the convention need be made here.

An amendment to the constitution adopted at the Washington convention in 1889 provided for the division of the Association into sections, or permanent committees as they were originally called. Sections have been organized in agriculture, botany, chemistry, college work, entomology, and horticulture. Their meetings were held during the recess of the general Association and consumed the greater part of the time allotted to the convention. They were taken up with discussions of a technical character.

At the first general meeting of the Association the chairmen of the sections elected at the last meeting were called upon for reports of progress made in their several lines of work at the stations and elsewhere during the past year. The papers presented justified the expectation of the last convention that these reports would furnish

a most important feature of the Association meetings. Especially full and valuable were the reports upon chemistry and entomology.

At the first public meeting, held on the evening of November 11, after short addresses by Regent Peabody, of the University of Indiana, by a representative of the city of Champaign, and by several members of the convention, President Smart's annual address was read. He laid stress upon the value and importance of technical and mechanical education and asserted its right to a place of honor by the side of the old classical and disciplinary college course.

In accordance with regulations that at each annual convention certain sections should present in the general session of the Association papers upon topics of especial importance, papers were read from the horticultural section on "The work of experiment stations in the reform of vegetable nomenclature," by L. H. Bailey, of New York, and on "Methods of work in variety testing," by W. J. Green, of Ohio. Both papers were well received and furnished the subjects of interesting discussions.

A. W. Harris, Assistant Director of the Office of Experiment Stations, read a paper outlining a plan for a co-operative exhibit by the Office of Experiment Stations and the experiment stations to be made in connection with the exhibit of the United States Department of Agriculture at the Columbian Exposition. A committee of five appointed to consider the matter reported the following resolutions, which were adopted:

Resolved, That, in the opinion of this Association, it is advisable to have a co-operative station exhibit at the World's Columbian Exposition,

Resolved, That to formulate and carry out such preliminary steps as are necessary during the year a special committee, with power to represent the Association, be appointed by this convention to co-operate with the Department of Agriculture and to take such other action as may be necessary.

Resolved, That the executive committee be authorized to pay from the funds of the Association the actual and necessary expenses incurred by the above-named committee in the discharge of its duties.

In pursuance of these resolutions the following committee was appointed: H. P. Armsby, Pennsylvania, chairman; G. E. Morrow, Illinois; C. E. Thorne, Ohio; S. M. Tracy, Mississippi; W. A. Henry, Wisconsin.

W. O. Atwater, Director of the Office of Experiment Stations, addressed the Association on the work of the Office. With other subjects he presented a plan for a co-operative index of station publications and other literature to be prepared by the Office of Experiment Stations for the stations. At the close of the convention an informal meeting of station directors and others interested was held for the consideration of this and other matters. The need of an index of station literature was very clearly brought out, and the Office was urged to begin its preparation as soon as practicable. The Association of Official Economical Entomologists held its sessions at the time of the convention, its meetings alternating with those of the section of entomology.

The following officers were elected for the ensuing year: President, H. H. Goodell of Massachusetts; vice-presidents, O. Clute of Michigan, A. Q. Holladay of North Carolina, E. D. Porter of Missouri, I. P. Roberts of New York, and J. W. Sanborn of Utah; secretary and treasurer, M. A. Scovell of Kentucky; executive committee, H. E. Alvord of Maryland, M. C. Fernald of Maine, H. H. Goodell of Massachusetts, W. M. Hays of Minnesota, J. A. Myers

of West Virginia, M. A. Scovell of Kentucky, and J. H. Smart of Indiana.

On the evening of the 13th of November, after the close of the convention, the delegates and visitors present were tendered a reception by Regent Peabody at his residence. After the convention some fifty members visited the Fat Stock Show in Chicago, at the invitation of the Illinois State Board of Agriculture.

THE TEACHINGS OF EXPERIENCE REGARDING THE WORK OF THE STATIONS.

Two years have passed since the stations organized under the act of Congress of March 2, 1887, fairly began their operations. Some of our stations have been established ten or even fifteen years. The European stations have an experience of forty years. It will be of interest to note briefly some of the information that experience has brought as to the methods and results of our station work, the success gained and in prospect, and especially as to the ways in which improvement can be made. Now that the stations have passed the period of organization they are subject to criticism from various sources. This is felt most keenly by the station workers themselves, and they are making strenuous efforts to discover the real needs of their work, and the best methods for accomplishing the ends for which the stations were created. At such a time it is highly important to distinguish between the real faults of our stations and those which are alleged as the result of misapprehension of the proper aims and methods of experimental inquiries in agriculture.

One way in which the work of the stations can be improved is by more specialization. One of the misfortunes of American universities and colleges is that the teachers have to cover too much ground. The experiment stations meet with the same difficulty. The men who manage them and do their work are expected to undertake more questions than they can properly handle or hope to solve. In this matter our stations are having the same experience that the European stations have gone through. The managers, the boards of control, and the station workers are anxious to meet the demands of the agriculture of their respective localities. These demands are numerous and pressing. It requires long experience to realize the full force of the truth, that to satisfactorily settle questions which seem simple requires a large amount of abstract and long-continued labor. To undertake too many questions means to study each superficially and to fail to obtain reliable answers. It is a real fault of the stations that they undertake too many lines of inquiry.

There is also need of more abstract research. One of the chief difficulties the stations have to meet is the demand for so-called practical as distinguished from scientific investigation. In this practical, pushing country of ours the idea is current that the profounder study is very appropriate for philosophers and for institutions devoted to abstract research, but that it is not in place where things for use in daily life and work are to be found out, whereas the fact is that the experiments which on the surface seem most practical are apt in the long run to be least useful. The inquiries which bring the best fruit, the results that are most important and useful for practical workers in their daily life, are those which reach down to the laws which underlie practice. The very things which

seem most abstruse are often of the most practical importance. Just the abstract inquiry which is often decried is what is wanted to bring the information that ordinary people need. It is safe to say that a very large amount of our experiment station work is wasted, or at least fails of its fullest usefulness because of the lack of such inquiry. The future usefulness of the stations will depend upon what they discover of permanent value, and that it is from such inquiry that this must come, and it is a real fault of the stations that they are doing relatively so much of so-called practical work, and so little of abstract investigation.

Closely connected with the demand for practical results is the failure in too many cases to secure skilled specialists for the experimental work of the stations. It is true in the experiment stations as it is in the university, the banking house, or the railroad office that expert men are required for expert work, and if the men lack the training the interests of the enterprise suffer. Of course we have to face the fact that a large number of stations have been suddenly called into being, and the country does not furnish enough of well-trained specialists. Fortunately a large number of young men of ambition and ability are realizing this fact and are putting themselves in training in the best schools and experiment stations in this country and in Europe, so that gradually the want will be supplied. Meanwhile it remains a real fault that the stations do not have enough specialists for the work, though under the circumstances this is more a misfortune than a fault.

Parallel with the two last-named difficulties is another, namely, that the stations are in numerous cases giving relatively too much attention to the experimenting on the farm and too little to the work of the laboratory. It seems perfectly natural to suppose that the best place to find out what farmers need to know about farming is on the farm where the farming is done. In some cases this is true. In the newer regions, where there is as yet very little of accumulated farming experience, the experiment stations may be called upon to gather more or less of such experience by practical farm work, and even where it has been gathered from years and generations of the experience of good farmers there still remain experiments which may be best conducted on the farm, but in general the farm should not be the essential feature but the adjunct of the station, one of the numerous appliances for its work. An experiment station is not and should not be a model farm. The man to do good farming is the good farmer; the man to do useful experimenting is the trained specialist.

With the pressing need of information of so many kinds, it is really too bad that when a given question has been studied the best methods of inquiry learned by long-continued and costly inquiry, our farmers should be without the results and our stations should be planning and conducting experiments on the same question as if no attention had been given it. Yet just this is the case with us to-day. During the past forty years experiment stations and kindred institutions in Europe have been at work on the same problems which perplex our farmers, and many important discoveries have been made and much valuable experience gained. But our farmers, and what is just now worse, many of our experiment station workers, are ignorant of what has been done. Hence the stations are in too many instances going over old ground, making old mistakes, and devoting precious time and energy to the study of problems already solved.

This is more their misfortune than their fault. They are eager to get light but are unable to do so. They have not the libraries, which would be very expensive, nor the training which is necessary to make good use of them, and which requires years of special study at home and abroad. Nor would they, if they had the training and the books, have the time to use them, so manifold and pressing are the duties of their routine work. As stated elsewhere, this Office is endeavoring to assist them in so far as its inadequate means will allow. It is then a real fault of our stations that they do not utilize the fruits of experience already obtained, but it is a fault for which they are not entirely responsible.

Another difficulty with the work of the stations is the indefiniteness of many of the experiments. The questions are often broad and general when they ought to be narrow and specific. The conditions are often such that instead of testing the question proposed, a number of complicating features are involved. In consequence the results are indefinite and inconclusive and lacking in practical value. A field experiment is made to test the effect of a given fertilizer, as cotton-seed meal alone or with other fertilizers on the growth of cotton, or nitrate, phosphate, and potash, singly or in combination, on the growth of corn. But the physical and chemical properties of the soil are not known, and the character of the subsoil, the amounts of water supplied by rain-fall and from below are not determined. There may be a large stock of available plant food at the disposal of the plant which will obscure the action of the fertilizers. The supply of both water and plant food vary on the different experimental plats. In short, a number of conditions materially affecting the growth of the plant and affecting it differently on the different plats, are entirely undetermined. There is no way to tell how much of the differences in yield are due to these and other unknown conditions and how much to the effect of the fertilizers. The results are of little value for the field and the farm where the experiment was made and of still less value anywhere else. There are two ways of getting rid of this difficulty. One is by better field experiments. For these it is necessary to find soil of uniform character without a large store of available plant food; to plan the experiments rationally; to study the geological, physical, and chemical characters of the soil and subsoil; to observe the temperature and rain-fall; to conduct the experiments in a number of places, and through series of years. The other way is to make experiments on a small scale in boxes, pots, or otherwise, in which the conditions can be thoroughly controlled. Then by making the questions very specific, that is to say, by testing the effects of given fertilizing materials on a given crop; by comparing the effects of different fertilizers on the same crop, or the same fertilizers on different crops, definite and reliable information will be obtained. When the principles are found out and explained to the farmer, he will be able to apply them to his own lands and his own crops and verify and supplement them by experiments of his own. This means the labor of years, but it is the only way to get the definite results that are wanted. The same principle applies in other kinds of experimental inquiry.

The advantage of division of labor is a fundamental principle of political economy. It needs to be applied more effectively to station work. It has already been urged that the individual stations are studying too many questions. The other side of this fact is that too many stations are studying the same question.

"United, we stand; divided, we fall," has been a cardinal doctrine of American statesmen from the days of the Revolution. People are finding that the principle has a wider application, especially to our industrial system. Farmers are applying it to their organizatons; shrewd corporations are making use of it in ways to conduce to their advantage. The stations need to apply it in co-operative experimenting. The individual station worker can do at best only a little and in a few narrow lines. The things which he can do are inextricably interwoven with those which his fellow-workers in other stations can and ought to do. It is proper that the stations should unite in the planning and in the execution of their work. By series of experiments on a common plan, rationally devised and carefully executed, more reliable results can be obtained, and obtained in much shorter time than in any other way. It is a real fault of the stations that their work is not better divided and that there is not more co-operation.

But while the stations are not doing all their work as well as it might be done, or as well as they will do it when they shall have had more experience, more trained experimenters and more help in collating the fruits of research and in planning and conducting their inquiries, the public are no less at fault in their demands upon the stations and their judgment of the merits of the work of the stations.

Among the causes of popular misapprehension are that people do not understand until they have had the experience how much labor and what a high order of scientific inquiry are needed to get reliable answers to seemingly simple, practical questions. The complaint is common that a station is too scientific, that it ought to deal more with the practical wants of the farmer. In most cases the real difficulty is the other way. The stations are, on the whole, doing too little of abstract research and too much of so-called practical work. The questions asked of them are more numerous than they can successfully grapple, many of these questions require years of painstaking investigation, and the more thoroughly scientific the work the quicker will the answer come and the more useful will it be.

There is also a mistaken idea in some quarters that the stations feel above the plain, hard-working farmer, and do not sympathize with his wants. No one who is familiar with the stations, has associated with their workers, and has listened to their discussions in the meetings in which they gather for conference, can fail to appreciate the fact that in general they are thoroughly in earnest to do the work intrusted to them, and that to this end they are faithfully trying to learn the farmers' needs and how they may best work to meet them.

In many localities the real nature and purpose of the work of the stations are not appreciated. An extreme example will illustrate this. At the beginning of its work a station most wisely planned a systematic inquiry into the soils of its State, the best methods for developing their productive capacity, the most advantageous crops to grow upon them, the best methods of culture of these crops, and the best ways of using the products for the feeding of animals. In other words, it planned a system of experimenting which would bring the largest benefit to the agriculture of the State and to that of other States as well. But the people at large who were not familiar with such inquiries did not rightly understand the situation; they saw that immediate practical results were not following rapidly; the work of the station did not receive full and hearty support, and just as it

was successfully begun the legislature provided for the removal of the station to another place, and it is to be feared that much of the work so well begun will meet with serious interruption.

The task of the stations is broad, complex, and difficult. In many of the States there is much preliminary work to be done in studying the agricultural capabilities of regions which have been only superficially explored; in other and older States the farmers must be aroused to the desirability of departing from traditional methods or of introducing new products. In large measure the conditions under which our stations are working are different from those which obtain in Europe and in the older countries of the world. The magnitude and diversity of the problems which they are set to solve are beyond all precedents in the lines of agricultural research. It requires great wisdom to make a right choice of the material for immediate investigation, and to adapt the principles of experimenting, founded on past experience, to the peculiar conditions of agriculture, which exist in such bewildering variety and complexity within the vast territory of the United States.

Our stations must not only seek after new truths, but they must also verify previous researches. They must apply well-known principles to new conditions. They must aid in the introduction of new products. Besides finding new principles and applying old ones they have to do a large amount of routine work in the protection of the farmer against fraud in fertilizers, seeds, and feeding stuffs, and they must for a considerable period at least aid in diffusing among the farmers elementary knowledge of the principles and processes of rational agriculture as taught by modern science and the advanced practice of the best farmers. Much of the energy of their officers is devoted to the answering of letters, to going about among the farmers, and to endeavoring in various ways to connect the stations as intimately as may be with the agriculture of their respective States. The large task which the stations have to perform may be better realized when we consider that as a rule there is only a single station for each State. Such great States as Pennsylvania, Illinois, and Texas have each only one station. The large problems which the farmers of each of those States are urging the stations to investigate are numbered by scores and the individual questions by hundreds, and yet, as we have seen, one of the first conditions of successful experimenting is that only a very few problems shall be undertaken and that these shall be worked upon systematically and through long periods of years.

Our station workers are to a large extent pioneers. Some of the problems they have to deal with have never been dealt with by men of science before. The settler who takes up new land in a new country can not have the careful methods of culture that are found in older regions. If our stations are wasteful and at times unsuccessful they have the enthusiasm and vigor of youth, the purpose to do their best, are already achieving much, and with kindly criticism and generous support their future success will be assured.

The public has a duty to the stations which it can not justly neglect—to study their operations, look into the details of their work, offer suggestions, and at the same time learn why things that are done are done in the way they are.

The stations need the active sympathy and support of every intelligent farmer. In many cases they will desire the co-operation of practical farmers in carrying out experiments or making observa-

tions. They also need, and in numerous cases have already received, financial aid from States, communities, societies, and individuals for the furtherance of the interests of agriculture in their respective States.

Very many of the station publications have, of course, been mainly reports of progress relating to incomplete investigations, from which positive conclusions can not yet be drawn. On the other hand, some of the results of experiment station work, especially in the case of the older stations, are of great importance. Their inspection of fertilizers has saved the farmers millions of dollars. Their investigations on the feeding of animals have already made important changes in the methods of the stock raiser. The business of dairying is being largely influenced by results of recent investigations at the stations. They are devising means by which the farmer may protect his crops and his animals against the ravages of disease. They are gaining and disseminating an amount of information which is of incalculable value. They are an educating influence of inestimable importance.

To impress upon the farmers of the country the necessity of applying intelligence and systematic effort to farming as to other forms of business will be of the greatest benefit to the country. There is every reason to believe that the stations are doing their share in this great work.

Few persons realize the magnitude and the usefulness of the movement represented by the agricultural experiment stations in the United States. This system, established and supported by Congress and aided by the several States, with the Department of Agriculture as its center, constitutes the most extensive enterprise for agricultural experimenting which any nation has organized. The results which are being constantly achieved show that while we supply the Old World with our agricultural produce, we are also vieing with it in the higher fields of inquiry and the use of brains in farming.

That the stations are receiving more attention from farmers, journalists, and legislators is a sure evidence of their growing strength and importance. Chiefly in those sections of our country where there is the most widespread ignorance, and consequently the most complete disregard of the demands of a progressive agriculture, have the stations encountered serious difficulties in their organization and in the prosecution of their work. In fact it may safely be claimed that the establishment of the stations was due to the growing sentiment among the masses of our people in favor of the application of science to the practical needs of our common life. It may, therefore, be confidently expected that as long as our stations are faithful to the high and important duties for which they were created and do not lose sight of the great problems they were set to solve in a vain endeavor to secure a cheap popularity by doing small things, they will gain a stronger place in the regard and support of the American people.

LIST OF PUBLICATIONS OF THE OFFICE OF EXPERIMENT STATIONS.

The following publications of this Office are intended for general distribution. Others which were printed for special use and are not of permanent importance, are not mentioned here:

Farmers' Bulletins:

No. 1.—The What and Why of Agricultural Experiment Stations; issued June, 1889.

No. 2.—The Work of the Agricultural Experiment Stations—Better Cows; Fibrin in Milk; Bacteria in Milk; Silos and Silage; Alfalfa; Field Experiments with Fertilizers; issued June, 1890.

Experiment Station Bulletins:

No. 1.—Organization of the Agricultural Experiment Stations in the United States; issued February, 1889.

No. 2.—Digest of Annual Reports of Stations in the United States for 1888, Part I; issued June, 1889.

No. 3.—Report of Meeting of Horticulturists at Columbus, Ohio; issued July, 1889.

No. 4.—List of Horticulturists of the Agricultural Experiment Stations in the United States; issued November, 1889.

No. 5.—Organization List of the Agricultural Experiment Stations and Agricultural Schools and Colleges in the United States; issued March, 1890.

No. 6.—List of Botanists of the Agricultural Experiment Stations in the United States, with an Outline of the Work in Botany at the Several Stations; issued May, 1890.

Miscellaneous Bulletins:

No. 1.—Proceedings of Association of American Agricultural Colleges and Experiment Stations at Knoxville, Tennessee, January, 1889; issued March, 1889.

No. 2.—Proceedings of Association of American Agricultural Colleges and Experiment Stations at Washington, District of Columbia, November, 1889.

Circulars:

No. 7.—Co-operative Field Experiments with Fertilizers; issued March, 1889. This contains the report of the conference of representatives of stations regarding co-operative field experiments with fertilizers, directions and explanations for soil tests with fertilizers, and suggestions for further experiments.

No. 8.—Explanations and Directions for Soil Tests with Fertilizers; issued March, 1889. This is intended for the use of farmers experimenting under the direction of the stations. It is included in Circular No. 7, but was also printed separately for convenience.

No. 11.—Rules for Naming Vegetables, Report of Committee of Experiment Station Horticulturists; issued September, 1889.

Experiment Station Record:

Vol. I, 6 numbers, with index. Vol. II, 5 numbers, issued in 1890.

LIST OF AGRICULTURAL SCHOOLS AND COLLEGES IN THE UNITED STATES.

ALABAMA.—*Auburn:* Agricultural and Mechanical College, Alabama Polytechnic Institute; president, William LeRoy Broun, LL. D. *Abbeville:* Southeast Alabama Agricultural School; principal, J. S. Espy, M. A. *Athens:* North Alabama Agricultural School; principal, C. L. Newman, B. S.

ARIZONA.—*Tucson:* University of Arizona; president, Merrill P. Freeman.

ARKANSAS.—*Fayetteville:* Arkansas Industrial University; president, Edward Hunter Murfee, LL. D.

CALIFORNIA.—*Berkeley:* College of Agriculture of the University of California; president, Horace Davis, LL. D.; dean, Irving Stringham, Ph. D.

COLORADO.—*Fort Collins:* State Agricultural College of Colorado; president, Charles L. Ingersoll, M. S.

CONNECTICUT.—*Mansfield* (post-office, Storrs): Storrs Agricultural School; principal B. F. Koons, Ph. D. *New Haven:* Sheffield Scientific School of Yale University; president, Timothy Dwight, D.D., LL.D.; director, George J. Brush, LL. D.

DELAWARE.—*Newark:* Delaware College; president, Albert N. Raub, Ph. D.
FLORIDA.—*Lake City:* Florida State Agricultural and Mechanical College; president, Frank L. Kern, M. A.
GEORGIA.—*Athens:* Georgia State College of Agriculture and Mechanic Arts; chancellor, William E. Boggs, D. D., LL. D. *Cuthbert:* Southwest Georgia Agricultural College; president, A. J. Clark. *Dahlonega:* North Georgia Agricultural College; president, William S. Basinger, M. A. *Milledgeville:* Middle Georgia Military and Agricultural College; president, J. Colton Lynes, Ph. D. *Thomasville:* South Georgia College; president, G. M. Lovejoy. *Hamilton:* West Georgia Agricultural and Mechanical College; president, H. A. Hayes, B. A.
ILLINOIS.—*Urbana:* College of Agriculture of the University of Illinois; regent, Selim H. Peabody, Ph. D., LL. D.; dean, George E. Morrow, M. A.
INDIANA.—*La Fayette:* School of Agriculture, Horticulture, and Veterinary Science of Purdue University; president, James H. Smart, LL. D.
IOWA.—*Ames:* Iowa State College of Agriculture and Mechanic Arts; president, W. I. Chamberlain, LL. D.
KANSAS.—*Manhattan:* Kansas State Agricultural College; president, George T. Fairchild, M. A.
KENTUCKY.—*Lexington:* Agricultural and Mechanical College of Kentucky; president, James K. Patterson, Ph. D.
LOUISIANA.—*Baton Rouge:* Louisiana State University and Agricultural and Mechanical College; president, J. W. Nicholson, M. A.
MAINE.—*Orono:* Maine State College of Agriculture and the Mechanic Arts; president, Merritt C. Fernald, Ph. D.
MARYLAND.—*College Park:* Maryland Agricultural College; president, Henry E. Alvord, C. E.
MASSACHUSETTS.—*Amherst:* Massachusetts Agricultural College; president, Henry H. Goodell, M. A. *Jamaica Plain:* Bussey Institution of Harvard University; president, Charles W. Eliot, LL. D.; dean, F. H. Storer, B. S.
MICHIGAN.—*Agricultural College:* Michigan Agricultural College; president, Oscar Clute, M. S.
MINNESOTA.—*St. Anthony Park:* College of Agriculture of the University of Minnesota; president, Cyrus Northrop, LL. D. State School of Agriculture of the University of Minnesota; principal, W. W. Pendergast.
MISSISSIPPI.—*Agricultural College:* Agricultural and Mechanical College of Mississippi; president, S. D. Lee. *Rodney:* Alcorn Agricultural and Mechanical College; president, John H. Burrus, M. A.
MISSOURI.—*Columbia:* Agricultural and Mechanical School of the University of the State of Missouri; chairman of faculty, M. M. Fisher, D. D., LL.D.
NEBRASKA.—*Lincoln:* Industrial College of the University of Nebraska; president, Charles E. Bessey, Ph. D.
NEVADA.—*Reno:* School of Agriculture of the Nevada State University; president, Stephen A. Jones, Ph. D.
NEW HAMPSHIRE.—*Hanover:* New Hampshire College of Agriculture and the Mechanic Arts (in connection with Dartmouth College); president, Samuel C. Bartlett, D. D., LL. D.; dean, Charles H. Pettee, M. A., C. E.
NEW JERSEY.—*New Brunswick:* Rutgers Scientific School of Rutgers College; president, Austin Scott, Ph. D.
NEW MEXICO.—*Las Cruces:* Agricultural College of New Mexico; president, Hiram Hadley, M. A.
NEW YORK.—*Ithaca:* College of Agriculture of Cornell University; president, Charles Kendall Adams, LL. D.
NORTH CAROLINA.—*Raleigh:* The North Carolina College of Agriculture and Mechanic Arts; president, Alexander Q. Holladay.
NORTH DAKOTA.—*Fargo:* North Dakota Agricultural College; president, H. E. Stockbridge, Ph. D.
OHIO.—*Columbus:* Ohio State University; president, William H. Scott, LL. D.
OREGON.—*Corvallis:* Oregon State Agricultural College; president, B. L. Arnold, M. A.
PENNSYLVANIA.—*State College:* The Pennsylvania State College; president, George W. Atherton, LL. D.
RHODE ISLAND.—*Kingston:* Rhode Island State Agricultural School; president, John H. Washburn, Ph. D. *Providence:* Agricultural and Scientific Department of Brown University; president, Elisha Benjamin Andrews, D. D., LL. D.
SOUTH CAROLINA.—*Pendleton:* Clemson Agricultural College; president, H. A. Strode. *Orangeburgh:* Claflin University, College of Agriculture and Mechanics' Institute; president, L. M. Dunton, D. D.

SOUTH DAKOTA.—*Brookings:* South Dakota Agricultural College; president, Lewis McLouth, Ph. D.

TENNESSEE.—*Knoxville:* State Agricultural and Mechanical College of the University of Tennessee; president, Charles W. Dabney, jr., Ph. D., LL. D.; dean, Thomas W. Jordan, M. A.

TEXAS.—*College Station:* State Agricultural and Mechanical College of Texas; chairman of college faculty, Louis L. McInnis, M. A.

UTAH.—*Logan:* Agricultural College of Utah; president, J. W. Sanborn, B. S.

VERMONT.—*Burlington:* University of Vermont and State Agricultural College; president, Matthew H. Buckham, D. D.

VIRGINIA.—*Blacksburgh:* Virginia Agricultural and Mechanical College; president, L. L. Lomax. *Hampton:* Hampton Normal and Agricultural Institute; president, Samuel C. Armstrong, LL. D.

WEST VIRGINIA.—*Morgantown:* West Virginia University; president, E. M. Turner, LL. D.

WISCONSIN.—*Madison:* College of Agriculture of the University of Wisconsin; president, T. C. Chamberlin, Ph. D., LL. D.

The legal names, locations, and directors of the agricultural experiment stations in the United States.

State.	Name of station.	Location.	Director.
Alabama	Agricultural Experiment Station of the Agricultural and Mechanical College of Alabama.	Auburn	J. S. Newman.
Alabama	Canebrake Agricultural Experiment Station.	Uniontown	W. H. Newman, M. S. *a*
Alabama	North Alabama Branch Agricultural Experiment Station.	Athens	C. L. Newman, B. S.
Alabama	Southeast Alabama Agricultural Experiment Station.	Abbeville	T. M. Watlington, B. S.
Arizona	Agricultural Experiment Station of the University of Arizona.	Tucson	F. A. Gulley, M. S.
Arkansas	Arkansas Agricultural Experiment Station. (Substations at Newport and Pine Bluff.)	Fayetteville	A. E. Menke, D. Sc.
California	Agricultural Experiment Station of the University of California. (Substations at Cupertino, Fresno, Glen Ellen, Jackson, Mission San José, Paso Robles, Pomona, and Tulare.)	Berkeley	E. W. Hilgard, Ph. D., LL. D.
Colorado	Agricultural Experiment Station. (Substations at Del Norte and Rocky Ford.)	Fort Collins	C. L. Ingersoll, M. S.
Connecticut	The Connecticut Agricultural Experiment Station.	New Haven	S. W. Johnson, M. A.
Connecticut	Storrs School Agricultural Experiment Station.	Storrs	C. D. Woods, B. S. *b*
Delaware	The Delaware College Agricultural Experiment Station.	Newark	A. T. Neale, Ph. D.
Florida	Agricultural Experiment Station of Florida. (Substations at De Funiak and Fort Myers.)	Lake City	J. P. DePass.
Georgia	Georgia Experiment Station	Experiment *c*	R. J. Redding.
Illinois	Agricultural Experiment Station of the University of Illinois.	Champaign	S. H. Peabody, Ph. D., LL. D.
Indiana	Purdue University Agricultural Experiment Station.	La Fayette	J. H. Smart, LL. D. *b*
Iowa	Iowa Agricultural Experiment Station.	Ames	James Wilson.
Kansas	Kansas Agricultural Experiment Station.	Manhattan	G. T. Fairchild, M. A. *d*
Kentucky	Kentucky Agricultural Experiment Station.	Lexington	M. A. Scovell, M. S.
Louisiana	No. 1. Sugar Experiment Station	Audubon Park, New Orleans.	W. C. Stubbs, Ph. D.
Louisiana	No. 2. State Experiment Station	Baton Rouge	W. C. Stubbs, Ph. D.
Louisiana	No. 3. North Louisiana Experiment Station.	Calhoun	W. C. Stubbs, Ph. D.
Maine	Maine State College Agricultural Experiment Station.	Orono	W. H. Jordan, M. S.
Maryland	Maryland Agricultural Experiment Station.	College Park	H. E. Alvord, C. E.

a Assistant director in charge.
b Acting director.
c Freight and express office, Griffin.
d Chairman of Council.

The legal names, locations, and directors of the agricultural experiment stations in the United States—Continued.

State.	Name of station.	Location.	Director.
Massachusetts	Massachusetts State Agricultural Experiment Station.	Amherst	C. A. Goessmann, Ph. D. LL. D.
Massachusetts	Hatch Experiment Station of the Massachusetts Agricultural College.	Amherst	H. H. Goodell, M. A.
Michigan	Experiment Station of Michigan Agricultural College.	Agricultural College.	O. Clute, M. S.
Minnesota	Agricultural Experiment Station of the University of Minnesota.	St. Anthony Park.	N. W. McLain, LL. B.
Mississippi	Mississippi Agricultural Experiment Station.	Agricultural College.	S. M. Tracy, M. S.
Missouri	Missouri Agricultural College Experiment Station.	Columbia	E. D. Porter, Ph. D.
Nebraska	Agricultural Experiment Station of the University of Nebraska.	Lincoln	H. H. Nicholson, M. A.
Nevada	Nevada Agricultural Experiment Station.	Reno	S. A. Jones, Ph. D.
New Hampshire	New Hampshire Agricultural Experiment Station.	Hanover	G. H. Whitcher, B. S.
New Jersey	New Jersey State Agricultural Experiment Station.	New Brunswick	J. Neilson. *b*
New Jersey	New Jersey Agricultural College Experiment Station.	New Brunswick	J. Neilson. *b*
New Mexico	Agricultural Experiment Station of New Mexico.	Las Cruces	H. Hadley, M. A.
New York	New York Agricultural Experiment Station.	Geneva	P. Collier, Ph. D.
New York	Cornell University Agricultural Experiment Station.	Ithaca	I. P. Roberts, M. Agr.
North Carolina	North Carolina Agricultural Experiment Station.	Raleigh	H. B. Battle, Ph. D.
North Dakota	North Dakota Agricultural Experiment Station.	Fargo	H. E. Stockbridge, Ph. D.
Ohio	Ohio Agricultural Experiment Station.	Columbus	C. E. Thorne.
Oregon	Oregon Experiment Station	Corvallis	B. L. Arnold, M. A.
Pennsylvania	The Pennsylvania State College Agricultural Experiment Station.	State College	H. P. Armsby, Ph. D.
Rhode Island	Rhode Island State Agricultural Experiment Station.	Kingston	C. O. Flagg, B. S.
South Carolina	South Carolina Agricultural Experiment Station.	Pendleton	H. A. Strode.
South Dakota	South Dakota Agricultural Experiment Station.	Brookings	L. Foster, M. S. A.
Tennessee	Agricultural Experiment Station of the University of Tennessee.	Knoxville	F. L. Scribner, B. S.
Texas	Texas Agricultural Experiment Station.	College Station	G. W. Curtis, M. S. A.
Utah	Agricultural Experiment Station of Utah.	Logan	J. W. Sanborn, B. S.
Vermont	State Agricultural Experiment Station.	Burlington	W. W. Cooke, M. A.
Virginia	Virginia Agricultural and Mechanical College Experiment Station.	Blacksburgh	W. D. Saunders.
West Virginia	West Virginia Agricultural Experiment Station.	Morgantown	J. A. Myers, Ph. D.
Wisconsin	Agricultural Experiment Station of the University of Wisconsin.	Madison	W. A. Henry, B. Agr.

Table showing the total number of members in the working staffs of experiment stations in the United States and the number of such officers devoted to different specialties.

NOTE.—A capital letter signifies that one of the number which it follows represents an officer who, having two titles and belonging by his first title in the column for which the letter stands, has already been entered there. Thus the entry G under entomologists and opposite Florida means that one officer is known as "botanist and entomologist," and has already been entered by his first title in the G or botanists column. Two letters indicate that two of the preceding number have been entered elsewhere.

Stations.	Number in staff.	A Directors.	B Secretaries and treasurers.	C Librarians.	D Clerks.	E In charge of substations.	F Agriculturists.	G Botanists.	H Biologists.	I Chemists.	K Entomologists.	L Geologists.	M Horticulturists.	N Irrigation engineers.	O Meteorologists.	P Mycologists.	Q Microscopists.	R Physicists.	S Veterinarians.	T Viticulturists.	U Miscellaneous.
Alabama (College)	11	2			1		3 A	2	1	4 A					1 G						
Alabama (Canebrake)	2	2					1 A														
Alabama (North)	1	1																			
Alabama (Southeast)	2	1																			*a* 1
Arizona	3	1								1			1								
Arkansas	9	1					3			2	1		1						1		
California	21	1			1	*b* 11	1 I	1		4 A	1 U	1 A	1 U							2 H	*c* 5 I
Colorado	12	1	1			2	2	1		2			2 G	1 O	2						
Connecticut (State)	10	2		1	1 C					4 A						1					*d* 3
Connecticut (Storrs)	5	2					2 A			2											
Delaware	5	1						1		1	1 M		1		1						
Florida	6	1				2	1 A	1		2	1 G										
Georgia	5	2	1 M				1			2 A			1		1 A						*e* 1 F
Illinois	9	1	1				2	2 M		1			2						1		
Indiana	9	1					2 A	2		2	1		1						1		
Iowa	12	1	1				2 A	3		3	1		1						1		
Kansas	13	1	1				2	2		2	2 M		2						1		*f* 1
Kentucky	7	1	1				1	1 K		3 A	1		1								
Louisiana (Sugar)	10	1	1							1											*g* 7
Louisiana (State)	9	2	2					1		2	1		1 K						1		
Louisiana (North)	3	1								1											*h* 1
Maine	10	1			1		1	2		2	2 GG				1				1		*f* 1
Maryland	7	1	1		1		1			1			1								*i* 1
Massachusetts (State)	10	1					2			7 A						1					
Massachusetts (Hatch)	10	1	1				2				1		3		1						*j* 1
Michigan	20	1	1	1			3	2	2	4	1		4						1		
Minnesota	7	1			1		2 A	1 K		1	1		1						1		
Mississippi	11	2	1				2	1 A		2	1 M		2		1				1		
Missouri	11	1	2				2 A			2	2 M		1						2		*k* 1
Nebraska	10	1	1				1	1		3 A	1							2			*f* 1

Nevada	8	2		1			2	1 K		1	1		1 F								*l* 1
New Hampshire	9	1			1		2 A	1		2					1		1 G				*m* 2
New Jersey (State)	6	1			1		1 I			3											*n* 1
New Jersey (College)	9	1		1	2 C			1 M	1	2	1		1								*k* 1
New Mexico	3	1					1 M	1 I		1			1								
New York (State)	7	2			1		1			2			1								
New York (Cornell)	13	2	2 A				2 A	2		2	2		2						1		*o* 1 E
North Carolina	10	1	1				1	1		4 A	1 G		2				1				
North Dakota	5	1						1		1									1		*o* 1
Ohio	10	2			1		1	2 K			1		1 A		1				1		*p* 2
Oregon	7	1					1	1		1	1		1								*k* 1
Pennsylvania	12	2			1		1	1		5 A			1								*q* 2
Rhode Island	6	1					1 A			1			1						1		*r* 2
South Carolina	3	2								1											
South Dakota	9	1		1	1		1 A	2 M		1	2		1						1		
Tennessee	8	1			1		1	1 A		2	1		1								*f* 1
Texas	7	1					2 A			2 O			1		1				1		*s* 1
Utah	5	1			1					1	1 M		1								*t* 1
Vermont	9	1	1				2 A	1		2	1		1				1				
Virginia	9	2	1			1	2 A	*u* 1 A		2	*u* 1 A		*u* 2 A						1		
West Virginia	6	1			1		1	1		2 A	1						1 G				
Wisconsin	8	1			1		1			2			1					1			*k* 1
Office of Experiment Stations	9																				
Total	438	66	21	5	18	16	63	42	4	101	33	1	47	1	11	2	4	3	19	2	42

a Foreman.
b Seven patrons and four foremen of substations.
c One superintendent of grounds, who is also horticulturist and entomologist; one œcologist, who is also first assistant chemist in viticultural laboratory; one foreman of station grounds, one foreman of cellars, and one inspector of stations.
d One grass agent, one superintendent of buildings and grounds, and one laboratory assistant.
e Dairyman.
f Foreman of farm.
g One engineer and assistant, one man in charge of diffusion battery, one sugar maker and two assistants, one farm manager.
h Farm manager.
i Machinist.
j Auditor.
k Farm superintendent.
l Superintendent of mechanical department.
m One dairyman and one general assistant.
n Laboratory assistant and janitor.
o Arboriculturist.
p One foreman of farm and one foreman of gardens.
q One superintendent of farm and one gardener.
r One apiarist and one farmer.
s Assistant to director.
t Superintendent.
u The vice director is also botanist, entomologist, and horticulturist.

The lines of work pursued

[The plus marks indi-

	Stations.	METEOROLOGY AND CLIMATOLOGY.	SOIL. Geology, physics, and chemistry.	SOIL. Tillage, drainage, and irrigation.	SOIL. Soil tests with fertilizers.	FERTILIZERS. Analyses without control.	FERTILIZERS. Analyses with control.	FERTILIZERS. Field experiments.	CROPS. Composition.	CROPS. Manuring and cultivation.	CROPS. Rotation.	CROPS. Varieties.	FEEDING STUFFS. Composition.	FEEDING STUFFS. Digestibility.	SILOS AND SILAGE.	FEEDING OF ANIMALS. For milk.	FEEDING OF ANIMALS. For beef.	FEEDING OF ANIMALS. For mutton.	FEEDING OF ANIMALS. For pork.	FEEDING OF ANIMALS. Methods.
1	Alabama (College)	+	×	×	+	×	+	+	×	+	×	+	×		+		×			
2	Alabama (Canebrake)	×		×	+			+	×	×	×	×			×		×		×	×
3	Alabama (North)			×	+			+		+	×	+								+
4	Alabama (Southeast)				+			+		×										
5	Arizona		×	×	×	×		×	×	×		×								
6	Arkansas	×			×		×	×	×	+	×	×	×	×	×		×			+
7	California	×	+	+	×	×		×	×	×		+								
8	Colorado	+	+	+					×	×	×	×	+				×		×	
9	Connecticut (State)				×		+	×	×	×			+							
10	Connecticut (Storrs)				+			+	+				×			+				
11	Delaware	+		×	+			+			×	×	+							
12	Florida		×	+	+	×		+	×	+	×	+			+					
13	Georgia	×	×	×	+			+	+	+	×	+	×							
14	Illinois	×		×		×		+	×	×	×	+	×		+		×		×	×
15	Indiana	×	×	×	×			+	×	×	×	×	×	×		×	×			
16	Iowa			+						×	×	×	+		×					
17	Kansas							×		+	×	+	×	×	+	×				
18	Kentucky		×	+	+	+		+	×	×	+	×	+	+		×	×	×	×	×
19	Louisiana (Sugar) }																			
20	Louisiana (State) }		×	+	+	+	+	+	+	+	+	+	+	+	×					
21	Louisiana (North) }																			
22	Maine	×			+		×	+	+			×	+	+	×	+		×	×	+
23	Maryland	×	×	×	×			+	×	×	+	×	×		+		+		×	+
24	Massachusetts (State)		×	×	+	+	+	+	+	+	×	+	+		+	+	+	+	+	×
25	Massachusetts (Hatch)	+			+			×	×			×	×		×					
26	Michigan	×		×	×	×		×	×	×	+	+	×	×	×		+		×	
27	Minnesota		×	×	×			×	×	×	×	×	×	×	×	×		×	×	×
28	Mississippi		×	+	+		×	+	×	+	×	+	×	×		+	×			
29	Missouri	×		×	×			×	+	+	+	+	+	+		+	+			+
30	Nebraska	+	×	×																
31	Nevada	×	+	+	×				×		×	×								
32	New Hampshire		×	×	+	×		+	×	×	+	×	+	×	+	+	×		+	×
33	New Jersey (State) }																			
34	New Jersey (College) }				×	×	+	+	+	×	×	×	×			+				
35	New Mexico			+							+									
36	New York (State)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×		×	×
37	New York (Cornell)			×	×	×		×	×	×	×	×	×		×	×		+	×	+
38	North Carolina	+		×	×		+	×	+	×	×	×	×	+	×	×	×			
39	North Dakota		×	+							×	×	+							
40	Ohio	×		×	+			+		×	×	+			×	×				×
41	Oregon			+	×					+	×	+	×	×	×	×				
42	Pennsylvania		×			+		+	×	×		×	+	+	+	+	×			
43	Rhode Island	×		×	×	×		×		×		×								
44	South Carolina										×	×								
45	South Dakota	+	+	×	×			×		×	+	+								
46	Tennessee			×	×	×			+	×		+	+			+	×		+	
47	Texas	×	×	×	×	×		×	×	×	×	×	×	×	×	+	+		+	
48	Utah	×	×	×	×			×	×	×	×	×	×		×	×	×	×	×	×
49	Vermont	×			×	×	+	×	×	×		×	+	×	+	+			×	
50	Virginia				×	×		×	×	+	+	+	×		×		×		×	×
51	West Virginia	×			+	×		+	×	×		×	×						×	
52	Wisconsin			+					+			+	+		+	+		+	+	+
	Totals	25	22	36	39	20	11	39	36	39	35	44	36	17	26	22	20	7	19	17

at the several stations.

cate specialties.]

Dairying.				Chemistry.		Botany.				Horticulture.							Veterinary science and practice.							
Chemistry of milk.	Bacteria of milk.	Creaming of milk.	Butter making and creameries.	Special analyses.	Methods of analysis.	Systematic and physiological.	Mycology.	Seeds.	Weeds.	Vegetables.	Small fruits.	Grapes.	Orchard fruits.	Nuts.	Forestry.	Entomology.	General.	Hog cholera.	Texas fever.	Dehorning.	Apiculture.	Aviculture.	Technology.—Sugars, wines, etc.	
+			×	×	+	+	+	×	×	+	+	+	+	×		+					×			1
										×	×	×	×	×										2
		+								+	×	+	+								+	×		3
												×	×											4
				×						×	×	×	×	×	×									5
				×						×	+	×	+			×	×		+					6
				+	×	+	×	×	+	×	×	+	+	+	×	×							×	7
				×				+	+	+	+	+	+		+						×			8
×				×	×		+	×								×								9
+	+	×	×	×	×								×											10
×			+		×		+	×	×	×	+	×	+			+	×						×	11
							×	+	+	×	×	+	+	×		+								12
										+	+	×	+	×										13
×		+	×	+	×		+	×	×	+	×	×	×		+								×	14
				×	×		×	×		×	×	×	×			×		×					×	15
+			×	+		×	×			×			+			+							×	16
				+	×		×	×		+	×	+	×		+	+	×	×			×		×	17
		×	×	×	×	×	×	×	×	×	×	×	×		×	+		×						18
				+	+	+			+	+	+	+	+			+	+	×	+				+	{19, 20, 21
+		×						×	×		×		×				×	×						22
				+	×		×			+	+	×	×		×									23
+		+	×	+	+	×	+	×			×	×	×		×									24
×										×	×	×	×			+								25
+		×		×				×	×	+	+	×	×	×		+	×				×			26
×			×	×		×	×			×	×	×	×		×	×	×						×	27
×			×	×		×	+			×	+	×	×	×		+								28
+	+	+	+	+	+		×	×	×	+	+	+	+			×	+	+	+	×	×	×	×	29
				×	×	+	+		×	×			×			+	×						+	30
				×	×	×		×	×	×	×	+	+		+	+								31
×	×	×	+		×	×																		32
+				×	×	×	×	×	×	×	×	×	×		×	×								{33, 34
									×	+	+	+	+	×	×									35
×		×	×	×	×			×		×	×	×	×		×	×						×	×	36
×		×		×	×		+	×	×	+	+	+	+			+				×				37
		×	×	+			×	+	×	+	×	×	×	×		×								38
×	×	×	×	+			+	×	×	×	×				+	×							×	39
						×	×		×	×	+	×	×		×	+	×	+						40
				×		×	×			×	×	×	×	×		+								41
				×	×			×		+	×				×									42
								×	×	+	+	×	+		×		×				+			43
																								44
				+	+	+	×		+	×	+		+		+	+	+			×				45
×			+	×	×		+													×				46
×		+	+	×		×	×	×	×	×	×	×	×	×	×	×	×		+	×			×	47
×										×	×	×	×		×	×								48
+		+	+	×	+		+		+	+	+	×	×			+	×							49
				+	×	×	+	×	×	+	+	+	+	×		×								50
+	×	+	+	+	+	+	×	×	+	×	×	×	+	×	+	+								51
+			+						+		+	+	+										+	52
24	5	16	19	34	25	18	28	25	26	40	41	38	43	14	21	31	14	7	4	5	7	3	14	

Revenues and additions to the equipment of the agricultural experiment stations in 1890, and the aggregate value of funds and other property received by them previous to 1890 from other sources than the United States.

Stations.	Revenue for 1890 from—								Aggregate value of funds and other property received previous to 1890 from other sources than the United States.	Value of additions to equipment in 1890.						
	United States.	States.	Local communities.	Individuals.	Fees.	Farm produce.	Miscellaneous.	Total.		Farm.	Buildings.	Library.	Apparatus.	Live stock.	Miscellaneous.	Total.
Alabama (College)	$13,000	$10,810			$410			$24,220	$36,500	$1,000	$750	$300	$3,500			$5,550
Alabama (Canebrake)	2,000	2,500						4,500	4,500							
Alabama (North)		2,500			250			2,750	15,000		4,500				$1,000	5,500
Alabama (Southeast)		2,500						2,500								
Arizona	15,000	10,000						25,000								
Arkansas	15,000		$2,000					17,000	2,000	1,800	750	300	1,500		1,000	5,850
California	15,000	19,940	3,000					37,940	79,400	585	1,428	421	897	$400		3,731
Colorado	15,000	54,923			1,006	$1,631	$1,242	73,802			29,160	688	2,046	1,000	2,000	34,894
Connecticut (State)	7,500	8,000					4,269	19,769	79,500			266				266
Connecticut (Storrs)	7,500			$125		64	146	7,835			900			198		1,098
Delaware	15,000							15,000		1,600	382	148	414			2,544
Florida	15,000							15,000			2,626	75	120			2,821
Georgia	15,000					400		15,400	19,000		6,232			300	225	6,757
Illinois	15,000							15,000				450	250		100	800
Indiana	15,000	15,000				2,000		32,000			12,000	3,500		1,500		17,000
Iowa	15,000					420	36	15,456		82	977	306	155	2,900	137	4,557
Kansas	15,000							15,000				211	415			626
Kentucky	15,000				1,965	346		17,311	7,244		505	500	911	800		2,716
Louisiana (Sugar), Louisiana (State), Louisiana (North)	15,000	7,500		10,000	5,000	1,500		39,000	78,200		18,000	1,000	4,500	500	2,500	26,500
Maine	15,000					427		15,427	357		4,500					4,500
Maryland	15,000	1,200						16,200			750	150	1,250	500	100	2,750
Massachusetts (State)		10,000			1,500	1,000		12,500	12,500		450	300	700		200	1,650
Massachusetts (Hatch)	15,000							15,000	1,200		2,700	305	700			3,705
Michigan	15,000		500		880	272	77	16,729	3,933	500	1,000	254	408	455		2,617
Minnesota	15,000	3,000				2,797		20,797			300			1,509		1,809
Mississippi	15,000						410	15,410	456		600	225	800		500	2,125
Missouri	15,000	15,500				1,754		32,254	104,000		4,000	100	250	400	400	5,150
Nebraska	15,000							15,000		225		550	2,371			3,146
Nevada	15,000							15,000			500	125	800		150	1,575
New Hampshire	15,000					3,000		18,000			3,000	300		80		3,380
New Jersey (State)		11,000						11,000				613	597	500		1,710
New Jersey (College)	15,000							15,000								
New Mexico	15,000							15,000		7,500	25,000	800	1,000		1,000	35,300
New York (State)		30,000			20,000			50,000		583	500	200	1,500	327	447	3,557
New York (Cornell)	15,000					300		15,300	200		750	135	350	125		1,360
North Carolina	15,000	2,000				200	94	17,294	12,000	300	650		400	150	75	1,575
North Dakota	7,500					100		7,600		12,800		500	2,000		1,150	16,450

Ohio	15,000	2,000				7,081		24,081			844	175	64	319	243	1,645
Oregon	15,000							15,000			175	258	200		95	728
Pennsylvania	15,000	3,000			6,996	2,467		27,463	40,642		16,000					16,000
Rhode Island	15,000							15,000	14,924	408	700	614	1,723	420	1,397	5,262
South Carolina	15,000							15,000								
South Dakota	15,000							15,000		196	275	75	475			1,021
Tennessee	15,000					250		15,250								
Texas	15,000					3,294		18,294	5,567		150		360		200	650
Utah	15,000	11,200				231		26,431		1,200	12,300	300	2,000	200	2,000	18,000
Vermont	15,000					1,000		16,000	14,350		4,011	100	929	540		5,580
Virginia	15,000					1,440	140	16,580	310		566	29	450	49	120	1,214
Washington	15,000							15,000								
West Virginia	15,000						53	15,053	6,000		750	102	850	277	1,707	2,686
Wisconsin	15,000	4,000				2,000		21,000			2,000	500	1,500	500		4,500
Total	652,500	226,573	5,500	10,125	38,607	33,974	6,467	973,146	537,883	28,779	161,681	14,875	36,325	13,949	16,745	272,355

REPORT OF THE CHIEF OF THE DIVISION OF GARDENS AND GROUNDS.

SIR: Having prepared, by your direction, as stated on page 44, a descriptive list of the more important economic plants at present contained in the collection of the Department, I beg to offer the same in place of the usual report of work done in my Division, believing it to be of sufficient interest to justify its publication in your Annual Report.

Very respectfully,

WILLIAM SAUNDERS,
Superintendent of Gardens and Grounds.

Hon. J. M. RUSK,
Secretary.

DESCRIPTIVE CATALOGUE OF PLANTS.

1. ABELMOSCHUS MOSCHATUS.—This plant is a native of Bengal. Its seeds were formerly mixed with hair powder, and are still used to perfume pomatum. The Arabs mix them with their coffee berries. In the West Indies the bruised seeds, steeped in rum, are used, both externally and internally, as a cure for snake bites.
2. ABRUS PRECATORIUS.—Wild liquorice. This twining, leguminous plant is a native of the East, but is now found in the West Indies and other tropical regions. It is chiefly remarkable for its small oval seeds, which are of a brilliant scarlet color, with a black scar at the place where they are attached to the pods. These seeds are much used for necklaces and other ornamental purposes, and are employed in India as a standard of weight, under the name of Rati. The weight of the famous Kohinoor diamond is known to have been ascertained in this way. The roots afford liquorice, which is extracted in the same manner as that from the true Spanish liquorice plant, the *Glycyrrhiza glabra.* Recently the claim was made that the weather could be foretold by certain movements of the leaves of this plant, but experimental tests have proved its fallacy.
3. ABUTILON INDICUM.—This plant furnishes fiber fit for the manufacture of ropes. Its leaves contain a large quantity of mucilage.
4. ABUTILON VENOSUM.—This malvaceous plant is common in collections, as are others of the genus. They are mostly fiber-producing species. The flowers of *A. esculentum* are used as a vegetable in Brazil.
5. ACACIA BRASILIENSIS.—This plant furnishes the Brazil wood, which yields a red or crimson dye, and is used for dyeing silks. The best quality is that received from Pernambuco.
6. ACACIA CATECHU.—The drug known as catechu is principally prepared from this tree, the wood of which is boiled down, and the decoction subsequently evaporated so as to form an extract much used as an astringent. The acacias are very numerous, and yield many useful products. Gum arabic is produced by several species, as *A. vera, A. Arabica, A. Adansonii, A. verek,* and others. It is obtained by spontaneous exudation from the trunk and branches, or by incisions made in the bark, from whence it flows in a liquid state, but

soon hardens by exposure to the air. The largest quantity of the gum comes from Barbary. Gum senegal is produced by *A. vera*. By some it is thought that the timber of *A. Arabica* is identical with the Shittim tree, or wood of the Bible. From the flowers of *A. farnesiana* a choice and delicious perfume is obtained, the chief ingredient in many valued "balm of a thousand flowers." The pods of *A. concinna* are used in India as a soap for washing; the leaves are used for culinary purposes, and have a peculiarly agreeable acid taste. The seeds of some species are used, when cooked, as articles of food. From the seeds of *A. Niopo* the Guahibo Indians prepare a snuff, by roasting the seeds and pounding them in a wooden platter. Its effects are to produce a kind of intoxication and invigorate the spirits. The bark of several species is extensively used for tanning, and the timber, being tough and elastic, is valuable for the manufacture of machinery and other purposes where great strength and durability are requisite.

7. ACACIA DEAL BATA.—The silver wattle tree of Australia. The bark is used for tanning purposes. It is hardy South.

8. ACACIA HOMOLOPHYLLA.—This tree furnishes the scented myall wood, a very hard and heavy wood, of an agreeable odor, resembling that of violets. Fancy boxes for the toilet are manufactured of it.

9. ACACIA MELANOXYLON.—The wood of this tree is called mayall wood in New South Wales. It is also called violet wood, on account of the strong odor it has of that favorite flower; hence it is in great repute for making small dressing cases, etc.

10. ACACIA MOLLISSIMA.—The black wattle tree of Australia, which furnishes a good tanning principle. These trees were first called wattles from being used by the early settlers for forming a network or wattling of the supple twigs as a substitute for laths in plastering houses.

11. ACROCOMIA SCLEROCARPA.—This palm grows all over South America. It is known as the great macaw-tree. A sweetish-tasted oil, called Mucaja oil, is extracted from the fruit and is used for making toilet soaps.

12. ADANSONIA DIGITATA.—The baobab tree, a native of Africa. It has been called the tree of a thousand years, and Humboldt speaks of it as "the oldest organic monument of our planet." Adanson, who traveled in Senegal in 1794, made a calculation to show that one of these trees, 30 feet in diameter, must be 5,150 years old. The bark of the baobab furnishes a fiber which is made into ropes and also manufactured into cloth. The fiber is so strong as to give rise to a common saying in Bengal, "as secure as an elephant bound with baobab rope." The pulp of the fruit is slightly acid, and the juice expressed from it is valued as a specific in putrid and pestilential fevers. The ashes of the fruit and bark, boiled in rancid palm oil, make a fine soap.

13. ADENANTHERA PAVONINA.—A tree that furnishes red sandal wood. A dye is obtained simply by rubbing the wood against a wet stone, which is used by the Brahmins for marking their foreheads after religious bathing. The seeds are used by Indian jewelers as weights, each seed weighing uniformly four grains. They are known as Circassian beans. Pounded and mixed with borax, they form an adhesive substance. They are sometimes used as food. The plant belongs to the Leguminosæ.

14. ADHATODA VASICA.—This plant is extolled for its charcoal in the manufacture of powder. The flowers, leaves, roots, and especially the fruit, are considered antispasmodic, and are administered in India in asthma and intermittent fevers.

15. ÆGLE MARMELOS.—This plant belongs to the orange family, and its fruit is known in India as Bhel fruit. It is like an orange; the thick rind of the unripe fruit possesses astringent properties, and, when ripe, has an exquisite flavor and perfume. The fruit and other parts of the plant are used for medicinal purposes, and a yellow dye is prepared from the skin of the fruits.

16. AGAVE AMERICANA.—This plant is commonly known as American aloe, but it is not a member of that family, as it claims kindred with the *Amaryllis* tribe of plants. It grows naturally in a wide range of climate, from the plains of South America to elevations of 10,000 feet. It furnishes a variety of products. The plants form impenetrable fences; the leaves furnish fibers of various qualities, from the fine thread known as pita-thread, which is used for twine, to the coarse fibers used for ropes and cables. Humboldt describes a bridge of upward of 130 feet span over the Chimbo in Quito, of which the main ropes (4 inches in diameter) were made of this fiber. It is also used for making paper. The juice, when the watery part is evaporated, forms a good

soap (as detergent as castile), and will mix and form a lather with salt water as well as with fresh. The sap from the heart leaves is formed into pulque. This sap is sour, but has sufficient sugar and mucilage for fermentation. This vinous beverage has a filthy odor, but those who can overcome the aversion to this fetid smell indulge largely in the liquor. A very intoxicating brandy is made from it. Razor strops are made from the leaves; they are also used for cleaning and scouring pewter.

17. AGAVE RIGIDA.—The sisal hemp, introduced into Florida many years ago, for the sake of its fiber, but its cultivation has not been prosecuted to a commercial success. Like many other of the best vegetable fibers found in leaves, it contains a gummy substance, which prevents the easy separation of the fiber from the pulp.

18. ALEURITES TRILOBA.—The candleberry tree, much cultivated in tropical countries for the sake of its nuts. The nuts or kernels, when dried and stuck on a reed, are used by the Polynesians as a substitute for candles and as an article of food; they are said to taste like walnuts. When pressed, they yield largely of pure palatable oil, as a drying oil for paint, and known as artists' oil. The cake, after the oil has been expressed, is a favorite food for cattle. The root of the tree affords a brown dye, which is used to dye cloths.

19. ALGAROBIA GLANDULOSA.—The mezquite tree, of Texas, occasionally reaching a height of 25 to 30 feet. It yields a very hard, durable wood, and affords a large quantity of gum resembling gum arabic, and answering every purpose of that gum.

20. ALLAMANDA CATHARTICA.—This plant belongs to the family of *Apocynaceæ*, which contains many poisonous species. It is often cultivated for the beauty of its flowers; the leaves are considered a valuable cathartic, in moderate doses, especially in the cure of painter's colic; in large doses they are violently emetic. It is a native of South America.

21. ALOE SOCOTRINA.—Bitter aloe, a plant of the lily family, which furnishes the finest aloes. The bitter, resinous juice is stored up in greenish vessels, lying beneath the skin of the leaf, so that when the leaves are cut transversely, the juice exudes, and is gradually evaporated to a firm consistence. The inferior kinds of aloes are prepared by pressing the leaves, when the resinous juice becomes mixed with the mucilaginous fluid from the central part of the leaves, and thus it is proportionately deteriorated. Sometimes the leaves are cut and boiled, and the decoction evaporated to a proper consistence. This drug is imported in chests, in skins of animals, and sometimes in large calabash-gourds, and although the taste is peculiarly bitter and disagreeable, the perfume of the finer sorts is aromatic, and by no means offensive. It is common in tropical countries.

22. ALSOPHILA AUSTRALIS.—This beautiful tree-fern attains a height of stem of 25 to 30 feet, with fronds spreading out into a crest 26 feet in diameter. These plants are among the most beautiful of all vegetable productions, and in their gigantic forms indicate, in a meager degree, the extraordinary beauty of the vegetation on the globe previous to the formation of the coal measures.

23. ALSTONIA SCHOLARIS.—The Pali-mara, or devil tree, of Bombay. The plant attains a height of 80 or 90 feet; the bark is powerfully bitter, and is used in India in medicine. It is of the family of *Apocynaceæ*.

24. AMOMUM MELEGUETTA.—Malaguetta pepper, or grains of paradise; belonging to the ginger family, *Zingiberaceæ*. The seeds of this and other species are imported from Guinea; they have a very warm and camphor-like taste, and are used to give a fictitious strength to adulterated liquors, but are not considered particularly injurious to health. The seeds are aromatic and stimulating, and form, with other seeds of similar plants, what are known as cardamoms.

25. AMYRIS BALSAMIFERA.—This plant yields the wood called Lignum Rhodium. It also furnishes a gum resin analogous to Elemi, and supposed to yield Indian Bdellium.

26. ANACARDIUM OCCIDENTALE.—The cashew nut tree, cultivated in the West Indies and other tropical countries. The stem furnishes a milky juice, which becomes hard and black when dry, and is used as a varnish. It also secretes a gum, like gum arabic. The nut or fruit contains a black, acrid, caustic oil, injurious to the lips and tongue of those who attempt to crack the nut with their teeth; it becomes innocuous and wholesome when roasted, but this process must be carefully conducted, the acridity of the fumes producing severe inflammation of the face if approached too near.

27. ANANASSA SATIVA.—The well-known pineapple, the fruit of which was described three hundred years ago, by Jean de Lery, a Huguenot priest, as being of such excellence that the gods might luxuriate upon it, and that it should only be gathered by the hand of a Venus. It is supposed to be a native of Brazil, and to have been carried from thence to the West, and afterwards to the East Indies. It first became known to Europeans in Peru. It is universally acknowledged to be one of the most delicious fruits in the world. Like all other fruits that have been a long time under cultivation, there are numerous varieties that vary greatly, both in quality and appearance. The leaves yield a fine fiber, which is used in the manufacture of pina cloth; this cloth is very delicate, soft, and transparent, and is made into shawls, scarfs, handkerchiefs, and dresses.

28. ANDIRA INERMIS.—This is a native of Senegambia. Its bark is anthelmintic, but requires care in its administration, being powerfully narcotic. It has a sweetish taste, but a disagreeable smell, and is generally given in the form of a decoction, which is made by boiling an ounce of the dried bark in a quart of water until it assumes the color of Madeira wine. Three or four grains of the powdered bark acts as a powerful purgative. The bark is known as bastard cabbage bark, or worm bark. It is almost obsolete in medicine.

29. ANDROPOGON MURICATUS.—The Khus-Khus, or Vetiver grass of India. The fibrous roots yield a most peculiar but pleasing perfume. In India the leaves are manufactured into awnings, blinds, and sunshades; but principally for screens, used in hot weather for doors and windows, which, when wetted, diffuse a peculiar and refreshing perfume, while cooling the air.

30. ANDROPOGON SCHÆNANTHUS.—The sweet-scented lemon grass, a native of Malabar. An essential oil is distilled from the leaves, which is used in perfumery. It is a favorite herb with the Asiatics, both for medicinal and culinary purposes. Tea from the dried leaves is a favorite beverage of some persons.

31. ANONA CHERIMOLIA.—The Cherimoyer of Peru, where it is extensively cultivated for its fruits, which are highly esteemed by the inhabitants, but not so highly valued by those accustomed to the fruits of temperate climates. The fruit, when ripe, is of a pale greenish-yellow color, tinged with purple, weighing from 3 to 4 pounds; the skin thin; the flesh sweet, and about the consistence of a custard; hence often called custard apple.

32. ANONA MURICATA.—The sour-sop, a native of the West Indies, which produces a fruit of considerable size, often weighing over 2 pounds. The pulp is white and has an acrid flavor, which is not disagreeable.

33. ANONA RETICULATA.—The common custard apple of the West Indies. It has a yellowish pulp and is not so highly esteemed as an article of food as some others of the species. It bears the name of Condissa in Brazil. The Anonas are grown to some extent throughout southern Florida.

34. ANONA SQUAMOSA.—The sweet-sop, a native of the Malay Islands, where it is grown for its fruits. These are ovate in shape, with a thick rind, which incloses a luscious pulp. The seeds contain an acrid principle, and, being reduced to powder, form an ingredient for the destruction of insects.

35. ANTIARIS INNOXIA.—The upas tree. Most exaggerated statements respecting this plant have passed into history. Its poisonous influence was said to be so great as not only to destroy all animal life but even plants could not live within 10 miles of it. The plant has no such virulent properties as the above, but, as it inhabits low valleys in Java where carbonic acid gas escapes from the crevices in volcanic rocks which frequently proves fatal to animals, the tree was blamed wrongly. It is, however, possessed of poisonous juice, which, when dry and mixed with other ingredients, forms a venomous poison for arrows, and severe effects have been felt by those who have climbed upon the branches for the purpose of gathering the flowers.

36. ANTIARIS SACCIDORA.—The sack tree; so called from the fibrous bark being used as sacks. For this purpose young trees of about a foot in diameter are selected and cut into junks of the same length as the sack required. The outer bark is then removed and the inner bark loosened by pounding, so that it can be separated by turning it inside out. Sometimes a small piece of the wood is left to form the bottom of the sack. The fruit exudes a milky, viscid juice, which hardens into the consistency of beeswax, but becomes black and shining.

37. ANTIDESMA BUNIAS.—An East India plant which produces small, intensely black fruit about the size of a currant, used in making preserves. The bark

furnishes a good fiber, which is utilized in the manufacture of ropes. A decoction of the leaves is a reputed cure for snake bites. The whole plant is very bitter.

38. ARALIA PAPYRIFERA.—The Chinese rice paper plant. The stems are filled with pith of very fine texture and white as snow, from which is derived the article known as rice paper, much used in preparing artificial flowers.

39. ARAUCARIA BIDWILLI.—The Bunya-Bunya of Australia, which forms a large tree, reaching from 150 to 200 feet in height. The cones are very large, and contain one hundred to one hundred and fifty seeds, which are highly prized by the aborigines as food. They are best when roasted in the shell, cracked between two stones and eaten while hot. In flavor they resemble roasted chestnuts. During the season of the ripening of these seeds the natives grow sleek and fat. That part of the country where these trees most abound is called the Bunya-Bunya country.

40. ARAUCARIA BRASILIENSIS.—The Brazilian Araucaria, which grows at great elevations. The seeds of this tree are commonly sold in the markets of Rio Janeiro as an article of food. The resinous matter which exudes from the trunk is employed in the manufacture of candles.

41. ARAUCARIA CUNNINGHAMI.—The Morton Bay pine. This Australian tree forms a very straight trunk, and yields a timber of much commercial importance in Sidney and other ports. It is chiefly used for house building and some of the heavier articles of furniture.

42. ARAUCARIA EXCELSA.—This very elegant evergreen is a native of Norfolk Island. Few plants can compare with it in beauty and regularity of growth. The wood is of no particular value, although used for building purposes in Norfolk Island.

43. ARDISIA CRENATA.—A native of China. The bark has tonic and astringent properties, and is used in fevers and for external application in the cure of ulcers, etc.

44. ARECA CATECHU.—This palm is cultivated in all the warmer parts of Asia for its seed. This is known under the name of betel nut, and is about the size of a nutmeg. The chewing of these nuts is a common practice of hundreds of thousands of people. The nut is cut into small pieces, mixed with a small quantity of lime, and rolled up in leaves of the betel pepper. The pellet is chewed, and is hot and acrid, but possesses aromatic and astringent properties. It tinges the saliva red and stains the teeth. The practice is considered beneficial rather than otherwise, just as chewing tobacco-leaves, drinking alcohol, and eating chicken-salad are considered healthful practices in some portions of the globe. A kind of catechu is obtained by boiling down the seeds to the consistence of an extract, but the chief supply of this drug is Acacia catechu.

45. ARGANIA SIDEROXYLON.—This is the argan tree of Morocco. It is remarkable for its low-spreading mode of growth. Trees have been measured only 16 feet in height, while the circumference of the branches was 220 feet. The fruit is much eaten and relished by cattle. The wood is hard and so heavy as to sink in water. A valuable oil is extracted from the seeds.

46. ARISTOLOCHIA GRANDIFLORA.—The pelican flower. This plant belongs to a family famed for the curious construction of their flowers, as well as for their medical qualities. In tropical America various species receive the name of "Guaco," which is a term given to plants that are used in the cure of snake bites. Even some of our native species, such as *A. serpentaria*, is known as snake-root, and is said to be esteemed for curing the bite of the rattlesnake. It is stated that the Egyptian jugglers use some of these plants to stupify the snakes before they handle them. *A. bracteata* and *A. indica* are used for similar purposes in India. It is said that the juice of the root of *A. anguicida*, if introduced into the mouth of a serpent, so stupefies it that it may be handled with impunity. The Indians, after having "guaconized" themselves, that is, having taken Guaco, handle the most venomous snakes without injury.

47. ARTANTHE ELONGATA.—A plant of the pepper family, which furnishes one of the articles known by the Peruvians as Matico, and which is used by them for the same purposes as cubebs; but its chief value is as a styptic, an effect probably produced by its rough under surface, acting mechanically like lint. It has been employed internally to check hemorrhages, but with doubtful

effect. Its aromatic bitter stimulant properties are like those of cubebs, and depend on a volatile oil, a dark-green resin, and a peculiar bitter principle called *maticin*.

48. ARTOCARPUS INCISA.—This is the breadfruit tree of the South Sea Islands, where its introduction gave occasion for the historical incidents arising from the mutiny of the "Bounty." The round fruits contain a white pulp, of the consistence of new bread. It is roasted before being eaten, but has little flavor. The tree furnishes a viscid juice containing caoutchouc, which is used as glue for calking canoes. In the South Sea Islands the breadfruit constitutes the principal article of diet; it is prepared by baking in an oven heated by hot stones.

49. ARTOCARPUS INTEGRIFOLIA.—The jack of the Indian Archipelago, cultivated for its fruit, which is a favorite article among the natives, as also are the roasted seeds. The wood is much used, and resembles mahogany. Bird-lime is made from the juice.

50. ASTROCARYUM VULGARE.—Every part of this South American palm is covered with sharp spines. It is cultivated to some extent by the Indians of Brazil for the sake of its young leaves, which furnish a strong fiber for making bow-strings, fishing nets, etc. The finer threads are knitted into hammocks, which are of great strength. It is known as Tucum thread. The pulp of the fruit furnishes an oil. In Guiana it is called the Aoura palm.

51. ATTALEA COHUNE.—This palm furnishes Cahoun nuts, from which is extracted cohune oil, used as a burning oil, for which purpose it is superior to cocoanut oil. Piassaba fiber is furnished by this and *A. funifera*, the seeds of which are known as Coquilla nuts; these nuts are 3 or 4 inches long, oval, of a rich brown color, and very hard; they are much used by turners for making the handles of doors, umbrellas, etc. The fiber derived from the decaying of the cellular matter at the base of the leaf-stalks is much used in Brazil for making ropes. It is largely used in England and other places for making coarse brooms, chiefly used in cleaning streets.

52. AVERRHOA BILIMBI.—This is called the blimbing, and is cultivated to some extent in the East Indies. The fruit is oblong, obtuse-angled, somewhat resembling a short, thick cucumber, with a thin, smooth, green rind, filled with a pleasant, acid juice.

53. AVERRHOA CARAMBOLA.—The caramba of Ceylon and Bengal. The fruit of this tree is about the size of a large orange, and, when ripe, is of a rich yellow color, with a very decided and agreeable fragrance. The pulp contains a large portion of acid, and is generally used as a pickle or preserve. In Java it is used both in the ripe and unripe state in pies; a sirup is also made of the juice, and a conserve of the flowers. These preparations are highly valued as remedies in fevers and bilious disorders.

54. BACTRIS MAJOR.—The Marajah palm, of Brazil, which grows upon the banks of the Amazon River. It has a succulent, rather acid fruit, from which a vinous beverage is prepared. *B. minor* has a stem about 14 feet high and about an inch in diameter. These stems are used for walking canes, and are sometimes called Tobago canes.

55. BALSAMOCARPON BREVIFOLIUM.—This shrub is the algarrobo of the Chilians. It belongs to the pea family. Its pods are short and thick, and when unripe contain about 80 per cent of tannic acid; the ripe pods become transformed into a cracked resinous substance, when their tanning value is much impaired; this resinous matter is astringent, and is used for dyeing black and for making ink.

56. BALSAMODENDRON MYRRHA.—A native of Arabia Felix, producing a gum resin, sometimes called Opobalsamum, which was considered by the ancients as a panacea for almost all the ills that flesh is heir to. *B. Mukul* yields a resin of this name, and is considered identical with the Bdellium of Dioscorides and of the Scriptures. The resin has cordial and stimulating properties, and is burnt as an incense. In ancient times it was used as an embalming ingredient.

57. BAMBUSA ARUNDINACEA.—The bamboo cane, a gigantic grass, cultivated in many tropical and semitropical countries. The Chinese use it in one way or other for nearly everything they require. Almost every article of furniture in their houses, including mats, screens, chairs, tables, bedsteads, and bedding, is made made of bamboo. The masts, sails, and rigging of their ships consist chiefly of bamboo. A fiber has been obtained from the stem suitable for mixing

with wool, cotton, and silk; it is said to be very soft and to take dyes easily. They have treatises and volumes on its culture, showing the best soil and the seasons for planting and transplanting this useful production.

58. BAUHINIA VAHLII.—The Maloo-climber of India, where the gigantic shrubby stems often attain a height of 300 feet, running over the tops of the tallest trees, and twisting so tightly around their stems as to kill them. The exceedingly tough fibrous bark of this plant is used in India for making ropes and in the construction of suspension bridges. The seeds form an article of food; they are eaten raw, and resemble cashew nuts in flavor.

59. BEAUCARNEA RECURVIFOLIA.—This Mexican plant is remarkable for the large bulbiform swelling at the base of the stem. It is a plant of much elegance and beauty, resembling a drooping fountain.

60. BERGERA KONIGI.—The curry-leaf tree of India. The fragrant, aromatic leaves are used to flavor curries. The leaves, root, and bark are used medicinally. The wood is hard and durable, and from the seeds a clear, transparent oil, called Simbolee oil, is extracted.

61. BERRYA AMMONILLA.—This furnishes the Trincomalee wood of the Philippine Islands and Ceylon, and is largely used for making oil casks and for building boats, for which it is well adapted, being light and strong.

62. BERTHOLLETIA EXCELSA.—This furnishes the well known Brazil nuts, or cream nuts of commerce. The tree is a native of South America and attains a height of 100 to 150 feet. The fruit is nearly round and contains from eighteen to twenty-four seeds, which are so beautifully packed in the shell that when once removed it is found impossible to replace them. A bland oil is pressed from the seeds, which is used by artists, and at Para the fibrous bark of the tree is used for calking ships, as a substitute for oakum.

63. BIGNONIA ECHINATA.—A native of Mexico, where it is sometimes called Mariposa butterfly. The branches are said to be used in the adulteration of sarsaparilla. *B. chica*, a native of Venezuela, furnishes a red pigment, obtained by macerating the leaves in water, which is used by the natives for painting their bodies. The long flexible stems of *B. kerere* furnish the natives of French Guiana with a substitute for ropes. *B. alliacea* is termed the Garlic shrub, because of the powerful odor of garlic emitted from its leaves and branches when bruised. These plants all have showy flowers, and the genus is represented with us by such beautiful flowers as are produced by *B. radicans* and *B. capreolata*.

64. BIXA ORELLANA.—Arnotta plant. This plant is a native of South America, but has been introduced and cultivated both in the West and East Indies. It bears bunches of pink-colored flowers, which are followed by oblong bristled pods. The seeds are thinly coated with red, waxy pulp, which is separated by stirring them in water until it is detached, when it is strained off and evaporated to the consistence of putty, when it is made up into rolls; in this condition it is known as flag or roll arnotta, but when thoroughly dried it is made into cakes and sold as cake arnotta. It is much used by the South American Caribs and other tribes of Indians for painting their bodies, paint being almost their only article of clothing. As a commercial article it is mainly used as a coloring for cheese, butter, and inferior chocolates, to all of which it gives the required tinge without imparting any unpleasant flavor or unwholesome quality. It is also used in imparting rich orange and gold-colored tints to various kinds of varnishes.

65. BLIGHIA SAPIDA.—The akee fruit of Guinea. The fruit is about 3 inches long by 2 inches wide; the seeds are surrounded by a spongy substance, which is eaten. It has a subacid, agreeable taste. A small quantity of semisolid fatty oil is obtained from the seeds by pressure.

66. BŒHMERIA NIVEA.—A plant of the nettle family, which yields the fiber known as Chinese grass. The beautiful fabric called grasscloth, which rivals the best French cambric in softness and fineness of texture, is manufactured from the fiber of this plant. The fiber is also variously known in commerce as rheea, ramie, and in China as Tchow-ma. It is a plant of the easiest culture, and has been introduced into the Southern States, where it grows freely. When once machinery is perfected so as to enable its being cheaply prepared for the manufacturer, a great demand will arise for this fiber.

67. BOLDOA FRAGRANS.—A Chilian plant which yields small edible fruits; these, as well as all parts of the plant, are very aromatic. The bark is used for tanning, and the wood is highly esteemed for making charcoal. An alkaloid

called *boldine*, extracted from the plant, has reputed medicinal value, and a drug called Boldu is similarly produced.

68. BORASSUS FLABELLIFORMIS.—The Palmyra palm. The parts of this tree are applied to such a multitude of purposes that a poem in the Tamil language, although enumerating eight hundred uses, does not exhaust the catalogue. In old trees the wood becomes hard and is very durable. The leaves are from 8 to 10 feet long, and are used for thatching houses, making various mattings, bags, etc. They also supply the Hindoo with paper, upon which he writes with a stylus. A most important product called toddy or palm wine is obtained from the flower spikes, which yield a great quantity of juice for four or five months. Palm-toddy is intoxicating, and when distilled yields strong arrack. Very good vinegar is also obtained from it, and large quantities of jaggery or palm sugar are manufactured from the toddy. The fruits are large and have a thick coating of fibrous pulp, which is cooked and eaten or made into jelly. The young palm plants are cultivated for the market, as cabbages are with us, and eaten, either when fresh or after being dried in the sun.

69. BOSWELLIA THURIFERA.—This Coromandel tree furnishes the resin known as olibanum, which is supposed to have been the frankincense of the ancients. It is sometimes used in medicine as an astringent and stimulant, and is employed, because of its grateful perfume, as an incense in churches.

70. BROMELIA KARATAS.—The Corawa fiber, or silk-grass of Guiana, is obtained from this plant, which is very strong, and much used for bowstrings, fishing lines, nets, and ropes.

71. BROMELIA PINGUIN.—This is very common as a hedge or fence plant in the West Indies. The leaves, when beaten with a blunt mallet and macerated in water, produce fibers from which beautiful fabrics are manufactured. The fruit yields a cooling juice much used in fevers.

72. BROSIUM ALICASTRUM.—The bread-nut tree of Jamaica. The nuts or seeds produced by this tree are said to form an agreeable and nutritious article of food. When cooked they taste like hazelnuts. The young branches and shoots are greedily eaten by horses and cattle, and the wood resembles mahogany, and is used for making furniture.

73. BROSIMUM GALACTODENDRON—The cow tree of South America, which yields a milk of as good quality as that from the cow. It forms large forests on the mountains near the town of Cariaco and elsewhere along the seacoast of Venezuela, reaching to a considerable height. In South America the cow tree is called Palo de Vaca, or Arbol de Leche. Its milk, which is obtained by making incisions in the trunk, so closely resembles the milk of the cow, both in appearance and quality, that it is commonly used as an article of food by the inhabitants of the places where the tree is abundant. Unlike many other vegetable milks, it is perfectly wholesome, and very nourishing, possessing an agreeable taste, and a pleasant balsamic odor, its only unpleasant quality being a slight amount of stickiness. The chemical analysis of this milk has shown it to possess a composition closely resembling some animal substances; and, like animal milk, it quickly forms a cheesy scum, and after a few days' exposure to the atmosphere, turns sour and putrifies. It contains upwards of 30 per cent of a resinous substance called *galactine*.

74. BRYA EBENUS.—Jamaica or West India ebony tree. This is not the plant that yields the true ebony-wood of commerce. Jamica ebony is of a greenish-brown color, very hard, and so heavy that it sinks in water. It takes a good polish, and is used by turners for the manufacture of numerous kinds of small wares.

75. BYRSONIMA SPICATA.—A Brazilian plant, furnishing an astringent bark used for tanning, and also containing a red coloring matter employed in dyeing. The berries are used in medicine, and a decoction of the roots is used for ulcers.

76. CÆSALPINIA BONDUC.—A tropical plant, bearing the seeds known as nicker nuts, or bonduc nuts. These are often strung together for necklaces. The kernels have a very bitter taste, and the oil obtained from them is used medicinally.

77. CÆSALPINA PULCHERRIMA.—This beautiful flowering leguminous plant is a native of the East Indies, but is cultivated in all the tropics. In Jamaica it is called the "Barbados flower." The wood is sought after for charcoal, and a decoction of the leaves and flowers is used in fevers.

78. CÆSALPINIA SAPPAN.—The brownish-red wood of this Indian tree furnishes the Sappan wood of commerce, from which dyers obtain a red color, principally used for dyeing cotton goods. Its root also affords an orange-yellow dye.

79. CALAMUS ROTANG.—This is one of the palms that furnish the canes or rattans used for chair bottoms, sides of pony-carriages, and similar purposes. It is a climbing palm and grows to an immense length; specimens 300 feet long have been exhibited, climbing over and amongst the branches of trees, supporting themselves by means of the hooked spines attached to the leaf stalks. *C. rudentum* and *C. viminalis* furnish flexible canes. In their native countries they are used for a variety of manufacturing purposes, also for ropes and cables used by junks and other coasting vessels. In the Himalayas they are used in the formation of suspension bridges across rivers and deep ravines. *C. scipionum* furnishes the well-known Malacca canes used for walking sticks. They are naturally of a rich brown color. The clouded and mottled appearance which some of these present is said to be imparted to them by smoking and steaming.

80. CALLISTEMON SALIGNUM.—A medium-sized tree from Australia; one of the many so-called tea trees of that country. The wood, which is very hard, is known as stone wood and has been used for wood engraving. Layers of the bark readily peel off; hence it also receives the name of paper-bark plant.

81. CALLITRIS QUADRIVALVIS.—This coniferous plant is a native of Barbary. It yields a hard, durable, and fragrant timber, and is much employed in the erection of mosques, etc., by the Africans of the North. The resin that exudes from the tree is used in varnish under the name of gum-sandarach. In powder it forms a principal ingredient of the article known as pounce.

82. CALOPHYLLUM CALABA.—This is called calaba tree in the West Indies, and an oil, fit for burning, is expressed from the seeds. In the West Indies these seeds are called Santa Maria nuts.

83. CALOTROPIS GIGANTEA.—The inner bark of this plant yields a valuable fiber, capable of bearing a greater strain than hemp. All parts of it abound in a very acrid milky juice, which hardens into a substance resembling gutta-percha; but in its fresh state it is a valuable remedy in cutaneous diseases. The bark of the root also possesses similar medical qualities; and its tincture yields *mudarine*, a substance that has the property of gelatinizing when heated, and returning to the fluid state when cool. Paper has been made from the silky down of the seeds.

84. CAMELLIA JAPONICA.—A well-known green-house plant, cultivated for its large double flowers. The seeds furnish an oil of an agreeable odor, which is used for many domestic purposes.

85. CAMPHORA OFFICINARUM.—This tree belongs to the Lauracæ. Camphor is prepared from the wood by boiling chopped branches in water, when, after some time, the camphor becomes deposited and is purified by sublimation. It is mainly produced in the island of Formosa. The wood of the tree is highly prized for manufacturing entomological cabinets. As the plant grows well over a large area in the more Southern States, it is expected that the preparation of its products will become a profitable industry.

86. CANELLA ALBA.—This is a native of the West Indies, and furnishes a pale olive-colored bark with an aromatic odor, and is used as a tonic. It is used by the natives as a spice. It furnishes the true canella bark of commerce, also known as white-wood bark.

87. CAPPARIS SPINOSA.—The caper plant, a native of the South of Europe and of the Mediterranean regions. The commercial product consists of the flower-buds, and sometimes the unripe fruits, pickled in vinegar. The wood and bark possess acrid qualities which will act as a blister when applied to the skin.

88. CARAPA GUIANENSIS.—A meliaceous plant, native of tropical America, where it grows to a height of 60 to 80 feet. The bark of this tree possesses febrifugal properties and is also used for tanning. By pressure, the seeds yield a liquid oil called carap-oil or crab-oil, suitable for burning in lamps.

89. CARICA PAPAYA.—This is the South American papaw tree, but is cultivated in most tropical countries. It is also known as the melon-apple. The fruit is of a dingy orange-color, of an oblong form, about 8 to 10 inches long, by 3 or 4 inches broad. It is said that the juice of the tree, or an infusion of the leaves and fruit, has the property of rendering tough fiber quite tender. Animals fed upon the fruit and leaves will have very tender and juicy flesh.

90. CARLUDOVICA PALMATA.—A pandanaceous plant from Panama and southward. Panama hats are made from the leaves of this plant. The leaves are cut when young, and the stiff parallel veins removed, after which they are slit into shreds, but not separated at the stalk end, and immersed in boiling water for a short time, then bleached in the sun.

91. CARYOCAR NUCIFERUM.—On the river banks of Guiana this grows to a large-sized tree. It yields the butter-nuts, or souari-nuts of commerce. These are of a flattened kidney shape, with a hard woody shell of a reddish-brown color, and covered with wart-like protuberances. The nuts are pleasant to eat, and yield, by expression, an oil called Piquia oil, which possesses the flavor of the fruit.

92. CARYOPHYLLUS AROMATICUS.—This myrtaceous plant produces the well-known spice called cloves. It forms a beautiful evergreen, rising from 20 to 30 feet in height. The cloves of commerce are the unexpanded flower-buds; they are collected by beating the tree with rods, when the buds, from the jointed character of their stalks, readily fall, and are received on sheets spread on purpose; they are then dried in the sun. All parts of the plant are aromatic, from the presence of a volatile oil. The oil is sometimes used in toothache and as a carminative in medicine.

93. CARYOTA URENS.—This fine palm is a native of Ceylon, and is also found in other parts of India, where it supplies the native population with various important articles. Large quantities of toddy, or palm-wine, are prepared from the juice, which, when boiled, yields very good palm sugar or jaggery, and also excellent sugar candy. Sago is also prepared from the central or pithy part of the trunk, and forms a large portion of the food of the natives. The fiber from the leaf stalk is of great strength; it is known as Kittool fiber, and is used for making ropes, brushes, brooms, etc. A woolly kind of scruf, scraped off the leaf stalks, is used for calking boats, and the stem furnishes a small quantity of wood.

94. CASIMIROA EDULIS.—A Mexican plant, belonging to the orange family, with a fruit about the size of an ordinary orange, which has an agreeable taste, but is not considered to be wholesome. The seeds are poisonous; the bark is bitter, and is sometimes used medicinally.

95. CASSIA ACUTIFOLIA.—The cassias belong to the leguminous family. The leaflets of this and some other species produce the well-known drug called senna. That known as Alexandria senna is produced by the above. East Indian senna is produced by *C. elongata*. Aleppo senna is obtained from *C. obovata*. The native species, *C. marylandica*, possesses similar properties. The seeds of *C. absus*, a native of Egypt, are bitter, aromatic, and mucilaginous, and are used as a remedy for ophthalmia. *C. fistula* is called the Pudding-Pipe tree, and furnishes the cassia pods of commerce. The seeds of *C. occidentalis*, when roasted, are used as a substitute for coffee in the Mauritius and in the interior of Africa.

96. CASTILLOA ELASTICA.—This is a Mexican tree, which yields a milky juice, forming caoutchouc, but is not collected for commerce except in a limited way.

97. CASUARINA QUADRIVALVIS.—This Tasmanian tree produces a very hard wood of a reddish color, often called Beef wood. It is marked with dark stripes, and is much used in some places for picture frames and cabinetwork. This belongs to a curious family of trees having no leaves, but looking like a gigantic specimen of Horse-tail grass, a weed to be seen in wet places.

98. CATHA EDULIS.—This plant is a native of Arabia, where it attains the height of 7 to 10 feet. Its leaves are used by the Arabs in preparing a beverage like tea or coffee. The twigs, with leaves attached, in bundles of fifty, and in pieces from 12 to 15 inches in length, form a very considerable article of commerce, its use in Arabia corresponding to that of the Paraguay tea in South America and the Chinese tea in Europe. The effects produced by a decoction of the leaves of Cafta, as they are termed, are described as similar to those produced by strong green tea, only more pleasing and agreeable. The Arab soldiers chew the leaves when on sentry duty to keep them from feeling drowsy. Its use is of great antiquity, preceding that of coffee. Its stimulating effects induced some Arabs to class it with intoxicating substances, the use of which is forbidden by the Koran, but a synod of learned Mussulmans decreed that, as it did not impair the health or impede the observance of religious duties, but only increased hilarity and good humor, it was lawful to use it.

99. CECROPIA PELTATA.—The South American trumpet tree, so called because its hollow branches are used for musical instruments. The Waupe Indians form

a kind of drum by removing the pith or center of the branches. The inner bark of the young branches yields a very tough fiber, which is made into ropes. The milky juice of the stem hardens into caoutchouc.

100. CEDRELA ODORATA.—This forms a large tree in the West India Islands, and is hollowed out for canoes; the wood is of a brown color and has a fragrant odor, and is sometimes imported under the name of Jamaica cedar.

101. CEPHÆLIS IPECACUANHA.—This Brazilian plant produces the true ipecacuanha, and belongs to the *Cinchonaceæ*. The root is the part used in medicine, it is knotty, contorted, and annulated, and of a grayish-brown color, and its emetic properties are due to a chemical principle called *emetin*.

102. CERATONIA SILIQUA.—The carob bean. This leguminous plant is a native of the countries bordering on the Mediterranean. The seed pods contain a quantity of mucilaginous and saccharine matter, and are used as food for cattle. Besides the name of carob beans, these pods are known as locust pods, or St. John's bread, from a supposition that they formed the food of St. John in the wilderness. It is now generally admitted that the locusts of St. John were the insects so called, and which are still used as an article of food in some of the Eastern countries. There is more reason for the belief that the husks mentioned in the parable of the prodigal son were these pods. The seeds were at one time used by singers, who imagined that they softened and cleared the voice.

103. CERBERA THEVETIA.—The name is intended to imply that the plant is as dangerous as Cerberus. The plant has a milky, poisonous juice. The bark is purgative; the unripe fruit is used by the natives of Travancore to destroy dogs, as its action causes their teeth to loosen and fall out.

104. CEREUS GIGANTEA.—The suwarrow of the Mexicans, a native of the hot, arid, and almost desert regions of New Mexico, found growing in rocky places, in valleys, and on mountain sides, often springing out of mere crevices in hard rocks, and imparting a singular aspect to the scenery of the country, its tall stems often reaching 40 feet in height, with upright branches looking like telegraph posts for signaling from point to point of the rocky mountains. The fruits are about 2 or 3 inches long, of a green color and oval form; when ripe they burst into three or four pieces, which curve back so as to resemble a flower. Inside they contain numerous little black seeds, imbedded in a crimson-colored pulp, which the Indians make into a preserve. They also eat the ripe fruit as an article of food.

105. CEREUS MACDONALDIÆ.—A night-blooming cereus, and one of the most beautiful. The flowers when fully expanded are over a foot in diameter, having numerous radiating red and bright orange sepals and delicately white petals. It is a native of the Honduras.

106. CEROXYLON ANDICOLA.—The wax palm of New Grenada, first described by Humboldt and Bonpland, who found it on elevated mountains, extending as high as the lower limit of perpetual snow. Its tall trunk is covered with a thin coating of a whitish waxy substance, giving it a marbled appearance. The waxy substance forms an article of commerce, and is obtained by scraping the trunk. It consists of two parts of resin and one wax, and, when mixed with one third of tallow, it makes very good candles. The stem is used for building purposes, and the leaves for thatching roofs.

107. CHAMÆDOREA ELEGANS.—This belongs to a genus of palms native of South America. The plant is of tall, slender growth; the stems are used for walking canes, and the young, unexpanded flower spikes are used as a vegetable.

108. CHAMÆROPS FORTUNII.—This palm is a native of the north of China, and is nearly hardy here. In China, the coarse brown fibers obtained from the leaves are used for making hats and also garments called So-e, worn in wet weather.

109. CHAMÆROPS HUMILIS.—This is the only European species of palm, and does not extend farther north than Nice. The leaves are commonly used in the south of Europe for making hats, brooms, baskets, etc. From the leaf fiber a material resembling horse hair is prepared, and the Arabs mix it with camel's hair for their tent covers.

110. CHAVICA BETEL.—This plant is found all over the East Indies, where its leaf is largely used by Indian natives as a masticatory. Its consumption is im-

mense, and has been said to equal that of tobacco by Western peoples. It is prepared for chewing by inclosing in the leaves a slice of the areca nut, and a small portion of lime. It is thought to act as a stimulant to the digestive organs, but causes giddiness and other unpleasant symptoms to those not accustomed to its use.

111. CHIOCOCCA RACEMOSA.—This plant is found in many warm countries, such as in southern Florida. It is called cahinca in Brazil, where a preparation of the bark of the root is employed as a remedy for snake bites. Almost every locality where snakes exist has its local remedies for poisonous bites, but they rarely prove to be efficient when truthfully and fairly tested.

112. CHLORANTHUS OFFICINALIS.—The roots of this plant are an aromatic stimulant, much used as medicine in the Island of Java; also, when mixed with anise, it has proved valuable in malignant smallpox.

113. CHLOROXYLON SWIETENIA.—The satinwood tree of tropical countries. It is principally used for making the backs of clothes and hair brushes, and for articles of turnery-ware; the finest mottled pieces are cut into veneers and used for cabinet-making.

114. CHRYSOBALANUS ICACO.—The cocoa plum of the West Indies. The fruits are about the size of a plum, and are of various colors, white, yellow, red, or purple. The pulp is sweet, a little austere, but not disagreeable. The fruits are preserved and exported from Cuba and other West India Islands. The kernels yield a fixed oil, and an emulsion made with them is used medicinally.

115. CHRYSOPHYLLUM CAINITO.—The fruit of this plant is known in the West Indies as the star apple, the interior of which, when cut across, shows ten cells, and as many seeds disposed regularly round the center, giving a star-like appearance, as stars are generally represented in the most reliable almanacs. It receives its botanic name from the golden silky color on the under side of the leaves.

116. CICCA DISTICHA.—This Indian plant is cultivated in many parts under the name of Otaheite gooseberry. The fruits resemble those of a green gooseberry. They have an acid flavor; are used for preserving or pickling, and eaten either in a raw state or cooked in various ways.

117. CINCHONA CALISAYA.—The yellow bark of Bolivia. This is one of the so-called Peruvian Bark trees. The discovery of the medicinal value of this bark is a matter of fable and conjecture. The name cinchona is derived from that of the wife of a viceroy of Peru, who is said to have taken the drug from South America to Europe in 1639. Afterwards the Jesuits used it; hence it is sometimes called Jesuit's bark. It was brought most particularly into notice when Louis XIV of France purchased of Sir R. Talbor, an Englishman, his heretofore secret remedy for intermittent fever, and made it public.

There are various barks in commerce classified under the head of Peruvian barks. Their great value depends upon the presence of certain alkaloid substances called quinine, cinchonine, and quinidine, which exist in the bark in combination with tannic and other acids. Quinine is the most useful of these alkaloids, and this is found in greatest quantities in Calisaya bark. The gray bark of Huanuco is derived from *Cinchona micrantha*, which is characterized by its yield of cinchonine, and the Loxa or Loja barks are furnished in part by *Cinchona officinalis*, and are especially rich in quinidine. There is some uncertainty about the trees that produce the various kinds of bark. These trees grow in the forests of Bolivia and Peru, at various elevations on the mountains, but chiefly in sheltered mountain valleys, and all of them at a considerable distance below the frost or snow line. They are destroyed by the slightest frost. Plants of various species have been distributed from time to time, in localities which seemed most favorable to their growth, but all reports from these distributions have, so far, been discouraging.

118. CINNAMOMUM CASSIA.—This furnishes cassia bark, which is much like cinnamon, but thicker, coarser, stronger, less delicate in flavor, and cheaper; hence it is often used to adulterate cinnamon. The unexpanded flower buds are sold as cassia buds, possessing properties similar to those of the bark. It is grown in southern China, Java, and tropical countries generally.

119. CINNAMOMUM ZEYLANICUM.—A tree belonging to Lauraceæ, which furnishes the best cinnamon. It is prepared by stripping the bark from the branches, when it rolls up into quills, the smaller of which are introduced into the

larger, and then dried in the sun. Cinnamon is much used as a condiment for its pleasant flavor, and its astringent properties are of medicinal value. It is cultivated largely in Ceylon. The cinnamon tree is too tender to become of commercial importance in the United States. Isolated plants may be found in southern Florida, at least it is so stated, but the area suited to its growth must be very limited.

120. CISSAMPELOS PAREIRA.—The velvet plant of tropical countries. The root furnishes the *Pareira brava* of druggists, which is used in medicine.

121. CITRUS AURANTIUM.—The orange, generally supposed to be a native of the north of India. It was introduced into Arabia during the ninth century. It was unknown in Europe in the eleventh century. Oranges were cultivated at Seville towards the end of the twelfth century, and at Palermo in the thirteenth. In the fourteenth century they were plentiful in several parts of Italy. There are many varieties of the orange in cultivation. The blood red, or Malta, is much esteemed; the fruit is round, reddish-yellow outside and the pulp irregularly mottled with crimson. The Mandarin or Tangerine orange has a thin rind which separates easily from the pulp, and is very sweet and rich. The St. Michael's orange is one of the most productive and delicious varieties, with a thin rind and very sweet pulp. The Seville or bitter orange is used for the manufacture of bitter tincture and candied orange-peel. The Bergamot orange has peculiarly fragrant flowers and fruit, from each of which an essence of a delicious quality is extracted.

122. CITRUS DECUMANA.—The shaddock, which has the largest fruit of the family. It is a native of China and Japan, where it is known as sweet ball. The pulp is acid or subacid, and in some varieties nearly sweet. From the thickness of the skin the fruit will keep a considerable time without injury.

123. CITRUS JAPONICA.—This is the Kum-quat of the Chinese. It forms a small tree, or rather a large bush, and bears fruit about the size of a large cherry. There are two forms, one bearing round fruits, the other long, oval fruits. This fruit has a sweet rind and an agreeably acid pulp, and is usually eaten whole without being peeled. It forms an excellent preserve, with sugar, and is largely used in this form.

124. CITRUS LIMETTA.—The lime, which is used for the same purposes as the lemon, and by some preferred, the juice being considered more wholesome and the acid more agreeable. There are several varieties, some of them being sweet and quite insipid.

125. CITRUS LIMONUM.—The lemon; this plant is found growing naturally in that part of India which is beyond the Ganges. It was unknown to the ancient Greeks and Romans. It is supposed to have been brought to Italy by the Crusaders. Arabian writers of the twelfth century notice the lemon as being cultivated in Egypt and other places. The varieties of the lemon are very numerous and valued for their agreeable acid juice and essential oil. They keep for a considerable time, especially if steeped for a short period in salt water.

126. CITRUS MEDICA.—The citron, found wild in the forests of northern India. The Jews cultivated the citron at the time they were under subjection to the Romans, and used the fruit in the Feast of the Tabernacles. There is no proof of their having known the fruit in the time of Moses, but it is supposed that they found it at Babylon, and brought it into Palestine. The citron is cultivated in China and Cochin-China. It is easily naturalized and the seeds are rapidly spread. In its wild state it grows erect; the branches are spiny, the flowers purple on the outside and white on the inside. The fruit furnishes the essential oil of citron and the essential oil of cedra. There are several varieties; the fingered citron is a curious fruit, and the Madras citron is very long and narrow; the skin is covered with protuberances.

127. CLUSIA ROSEA.—A tropical plant which yields abundantly of a tenacious resin from its stem, which is used for the same purpose as pitch. It is first of a green color, but when exposed to the air it assumes a brown or reddish tint. The Caribs use it for painting the bottoms of their boats.

128. COCCOLOBA UVIFERA.—Known in the West Indies as the seaside grape, from the peculiarity of the perianth, which becomes pulpy and of a violet color and surrounds the ripe fruit. The pulpy perianth has an agreeable acid flavor. An astringent extract is prepared from the plant which is used in medicine.

129. COCOS NUCIFERA.—The cocoanut palm. This palm is cultivated throughout the tropics so extensively that its native country is not known. One reason

of its extensive dissemination is that it grows so close to the sea that the ripe fruits are washed away by the waves and afterwards cast upon far-distant shores, where they soon vegetate. It is in this way that the coral islands of the Indian Ocean have become covered with these palms. Every part of this tree is put to some useful purpose. The outside rind or husk of the fruit yields the fiber from which the well-known cocoa matting is manufactured. Cordage, clothes, brushes, brooms, and hats are made from this fiber, and, when curled and dyed, it is used for stuffing mattresses and cushions. An oil is produced by pressing the white kernel of the nut which is used for cooking when fresh, and by pressure affords stearin, which is made into candles, the liquid being used for lamps. The kernel is of great importance as an article of food, and the milk affords an agreeable beverage. While young it yields a delicious substance resembling blanc-mange. The leaves are used for thatching, for making mats, baskets, hats, etc.; combs are made from the hard footstalk; the heart of the tree is used as we use cabbages. The brown fibrous net work from the base of the leaves is used as sieves, and also made into garments. The wood is used for building and for furniture. The flowers are used medicinally as an astringent and the roots as a febrifuge.

130. COCOS PLUMOSUS.—A Brazilian species, highly ornamental in its long, arching leaves, and producing quantities of orange-colored nuts, in size about as large as a chestnut, inclosed in an edible pulp.

131. COFFEA ARABICA.—The coffee plant, which belongs to the *Cinchonaceæ* and is a native of Abyssinia, but is now cultivated in many tropical regions. It can not be successfully cultivated in a climate where the temperature, at any season of the year, falls below 55 degrees, although it will exist where the temperature all but falls short of freezing, but a low fall of temperature greatly retards the ripening of the fruit. Ripe fruits are often gathered from plants in the extreme south of Florida. The beans or seeds are roasted before use, and by this process they gain nearly one half in bulk and lose about a fifth in weight. Heat also changes their essential qualities, causing the development of the volatile oil and peculiar acid to which the aroma and flavor are due. The berries contain theine; so also do the leaves, and in some countries the latter are preferred.

132. COFFEA LIBERICA.—The Liberian coffee, cultivated in Africa, of which country it is a native. This plant is of larger and stronger growth than the Arabian coffee plant and the fruit is larger. This species is of recent introduction to commerce, and although it was reported as being more prolific than the ordinary coffee plant, the statement has not been borne out in Brazil and Mexico, where it has been tested. It is also more tender than the older known species.

133. COLA ACUMINATA.—An African tree, which has been introduced into the West Indies and Brazil for the sake of its seeds, which are known as Cola, or Kola, or Goora nuts, and extensively used as a sort of condiment by the natives of Africa. A small piece of one of these seeds is chewed before each meal to promote digestion. It possesses properties similar to the leaves of coca and contains theine. These nuts have from time immemorial occupied a prominent place in the dietetic economy of native tribes in Africa, and the demand for them has established a large commercial industry in the regions where they are obtained.

134. COLOCASIA ESCULENTA.—This plant has been recommended for profitable culture in this country for its edible root-stock. It is cultivated in the Sandwich Islands under the name of Tara. The young leaves are cooked and eaten in the same manner as spinach or greens in Egypt. They are acrid, but lose their acridity when boiled, the water being changed. The roots are filled with starch, and have long been used as food in various semitropical countries.

135. CONDAMINEA MACROPHYLLA.—This plant belongs to the cinchona family, and contains tonic properties. The Peruvian bark gatherers adulterate the true cinchona bark with this, but it may be detected by its white inner surface, its less powerful bitter taste, and a viscidity not possessed by the cinchonas.

136. CONVOLVULUS SCAMMONIA.—This plant furnishes the scammony of the druggists.

137. COOKIA PUNCTATA.—A small-growing tree from China, which produces a fruit known as the Wampee. This fruit is a globular berry, with five or fewer compartments filled with juice. It is much esteemed in China.

138. COPAIFERA OFFICINALIS.—This tree yields balsam of copaiba, used in medicine. The balsam is collected by making incisions in the stem, when the liquor is said to pour out copiously; as it exudes it is thin and colorless, but immediately thickens and changes to a clear yellow. Like many other balsams, it is nearly allied to the turpentines; it has a moderately agreeable smell, and a bitter, biting taste of considerable duration. Distilled with water it yields a limpid essential oil.

139. COPERNICA CERIFERA.—The Carnuba, or wax palm of Brazil. It grows about 40 feet high, and has a trunk 6 or 8 inches thick, composed of very hard wood, which is commonly employed in Brazil for building and other purposes. The upper part of the young stem is soft, and yields a kind of sago, and the bitter fruits are eaten by the Indians. The young leaves are coated with wax, called Carnaub wax, which is detatched by shaking them, and then melted and run into cakes; it is harder than beeswax, and has been used for making candles. The leaves are used for thatch, and, when young, are eaten by cattle.

140. COPROSMA ROBUSTA.—A cinchonaceous shrub. The leaves of this plant were formerly used in some of the religious ceremonies of the New Zealanders.

141. CORDIA MYXA.—This produces succulent, mucilaginous, and emollient fruits, which are eaten. These qualities, combined with a slight astringency, have led to their use as pectorals, known as Sebestens. The wood of this tree is said to have furnished the material used by the Egyptians in the construction of their mummy cases; it is also considered to be one of the best woods for kindling fire by friction.

142. CORDYLINE AUSTRALIS.—The Australian Ti, or cabbage tree, a palm-like plant of 15 to 20 feet in height. The whole plant is fibrous, and it has been suggested as good for a paper-making material. The juice of the roots and stem contains a small amount of sugar, and has been employed for procuring alcohol.

143. CORYPHA UMBRACULIFERA.—The Talipot palm, a native of Ceylon, producing gigantic fan-like leaves. These leaves have prickly stalks 6 or 7 feet long, and when fully expanded form a nearly complete circle of 13 feet in diameter. Large fans made of these leaves are carried before people of rank among the Cinghalese; they are also commonly used as umbrellas, and tents are made by neatly joining them together; they are also used as a substitute for paper, being written upon with a stylus. Some of the sacred books of the Cinghalese are composed of strips of them. The hard seeds are used by turners.

144. COUROUPITA GUIANENSIS.—The fruit of this tree is called, from its appearance, the cannon-ball fruit; its shell is used as a drinking vessel, and when fresh the pulp is of an agreeable flavor.

145. CRATÆVA GYNANDRA.—This West Indian tree yields a small fruit which has a strong smell of garlic, hence it is called the garlic pear. The bark is bitter and used as a tonic.

146. CRESCENTIA CUJETE.—The calabash tree of the West Indies, where it is valued for the sake of its fruits, which resemble pumpkins in appearance and occasionally reach a diameter of 18 inches. Divested of their pulp, which is not edible, they serve various useful domestic purposes, for carrying water, and even as kettles for cooking. They are strong and light.

147. CROTON CALSAMIFERUM.—This West Indian shrub is sometimes called sea-side balsam or sage. A thick, yellowish, aromatic juice exudes from the extremities of the broken branches, or wherever the stem has been wounded. In Martinique a liquor called *Eau de Mantes* is distilled from this balsamic juice with spirits of wine. The young leaves and branches are used in warm baths, on account of their agreeable fragrance and reputed medicinal virtues.

148. CROTON ELEUTHERIA.—This plant furnishes cascarilla bark, used as an aromatic bitter tonic, having no astringency. It has a fragrant smell when burnt, on which account it has been mixed with smoking tobacco.

149. CROTON TIGLIUM.—A plant of the family *Euphorbiaceæ*, from the Indian Archipelago, which produces the seeds from whence croton oil is extracted. It is a very powerful medicine, and even in pressing the seeds for the purpose of extracting the oil, the workmen are subject to irritation of the eyes and other casualties

150. CUBEBA OFFICINALIS.—A native of Java, which furnishes the cubeb fruits of commerce. These fruits are like black pepper, but stalked, and have an acrid, hot, aromatic taste; frequently used medicinally.

151. CURCAS PURGANS.—A tropical plant cultivated in many warm countries for the sake of its seeds, known as physic nuts. The juice of the plant, which is milky, acrid, and glutinous, produces an indellible brown stain on linen. The oil from the seeds is used for burning in lamps; and in paints. In China it is boiled with oxide of iron and used as a varnish. It is also used medicinally.

152. CURCUMA LONGA.—A plant belonging to the *Zingiberaceæ*, the roots of which furnish turmeric. This powder is used in India as a mild aromatic, and for other medicinal purposes. It also enters into the composition of curry-powder, and a sort of arrow root is made from the young tubers.

153. CURCUMA ZEDOARIA.—This plant furnishes zedoary tubers, much used in India as aromatic tonics.

154. CYATHEA MEDULLARIS.—This beautiful tree fern is a native of Australia, where it attains a height of 25 to 30 feet, having fronds from 10 to 15 feet in length. It contains a pulpy substance in the center of the stem, of a starchy, mucilaginous nature, which is a common article of food with the natives. The trees have to be destroyed in order to obtain it.

155. CYBISTAX ANTISYPHILITICA.—A plant of the order of *Bignoniaceæ*, called Atunyangua in the Andes of Peru, where the inhabitants dye their cotton clothes by boiling them along with the leaves of this plant; the dye is a permanent blue. The bark of the young shoots is much employed in medicine.

156. CYCAS REVOLUTA.—The sago palm of gardens. The stem of the plants abounds in starch, which is highly esteemed in Japan. A gum exudes from the trunk of the old plant, which is employed medicinally by the natives of India.

157. CYCAS CIRCINALIS.—A native of Malabar, where a kind of sago is prepared from the seeds, which are dried and powdered; medicinal properties are also attributed to the seeds.

158. DACRYDIUM FRANKLINII.—Called Huon pine, because of its being found near the Huon River, in Tasmania. It belongs to the yew family. It furnishes valuable timber, very durable, and is used for ship and house building; some of the wood is very beautifully marked, and is used in furniture making and cabinetwork.

159. DALBERGIA SISSOO.—A tree of northern India, the timber of which is known as Sissum wood. This wood is strong, tenacious, and compact, much used for railway ties and for gun-carriages.

160. DAMARA AUSTRALIS.—A singular plant of the *Coniferæ* family, called the Kauri pine. It forms a tree 150 to 200 feet in height, and produces a hard, brittle resin-like copal, which is used in varnish.

161. DASYLIRION ACROTRICHUM.—A plant of the pineapple family, from Mexico. The leaves contain a fine fiber, which may be ultimately more extensively utilized than it is at present.

162. DESMODIUM GYRANS.—An interesting plant of the pea family, called the moving plant, on account of the rotatory motion of the leaflets. These move in all conceivable ways, either steadily or by jerks. Sometimes only one leaf or two on the plant will be affected; at other times a nearly simultaneous movement may be seen in all the leaves. These movements are most energetic when the thermometer marks about 80°. This motion is not due to any external or mechanical irritation.

163. DIALIUM ACUTIFOLIUM.—The velvet tamarind, so called, from the circumstance that its seed-pods are covered with a beautiful black velvet down. The seeds are surrounded by a farinaceous pulp of an agreeable acid taste.

164. DIALIUM INDUM.—The tamarind plum, which has a delicious pulp of slightly acid flavor.

165. DICKSONIA ANTARCTICA.—The large fern tree of Australia. This plant attains the height of 30 or more feet, and its fronds or leaves spread horizontally some 20 to 25 feet. It is found in snowy regions, and would be perfectly hardy south. It is one of the finest objects of the vegetable kingdom when of sufficient size to show its true beauties.

166. DIEFFENBACHIA SEGUINA.—This has acquired the name of dumb cane, in consequence of its fleshy, cane-like stems, rendering speechless any person

who may happen to bite them, their acrid poison causing the tongue to swell to an immense size. An ointment for applying to dropsical swellings is prepared by boiling the juice in lard. Notwithstanding its acridity, a wholesome starch is prepared from the stem.

167. DILLENIA SPECIOSA.—An East Indian tree, bearing a fruit which is used in curries and for making jellies. Its slightly acid juice, sweetened with sugar, forms a cooling beverage. The wood is very tough, and is used for making gun-stocks.

168. DION EDULE.—A Mexican plant, bearing large seeds containing a quantity of starch, which is separated and used as arrow root.

169. DIOSPYROS EBENUM.—An East Indian tree which in part yields the black ebony wood of commerce, much used in fancy cabinetwork and turnery, door knobs, pianoforte keys, etc.

170. DIOSPYROS KAKI.—The Chinese date plum or persimmon. The fruits vary in size from that of a medium-sized apple to that of a large pear; they also vary much in their flavor and consistency, some being firm, and others having a soft custard-like pulp, very sweet and luscious. The Chinese dry them in the sun and make them into sweetmeats; they are sometimes imported, and in appearance resemble large-sized preserved figs. These plants are being quite largely cultivated in some of the southern States, and the fruit is entering commerce.

171. DIPTERIX ODORATA.—This leguminous plant yields the fragrant seed known as Tonka bean, used in scenting snuff and for other purposes of prefumery. The odor resembles that of new-mown hay, and is due to the presence of *coumarine.* The tree is a native of Cayenne and grows 60 to 80 feet high.

172. DORSTENIA CONTRAYERVA.—A plant from tropical America, the roots of which are used in medicine under the name of Contrayerva root.

173. DRACÆNA DRACO.—The Dragon's Blood tree of Teneriffe. This liliaceous plant attains a great age and enormous size. The resin obtained from this tree has been found in the sepulchral caves of the Cuanches, and hence it is supposed to have been used by them in embalming the dead. Trees of this species, at present in vigorous health, are supposed to be as old as the pyramids of Egypt.

174. DRACÆNOPSIS AUSTRALIS.—Ti or cabbage tree of New Zealand. The whole of this plant is fibrous and has been used for paper making. The juice of the roots and stem contains a small amount of sugar and has been used for producing alcohol.

175. DRIMYS WINTERI.—This plant belongs to the magnolia family and furnishes the aromatic tonic known as Winter's bark. It is a native of Chili and the Strait of Magalhaens.

176. DRYOBALANOPS AROMATICA.—A native of the Island of Sumatra. It furnishes a liquid called camphor oil and a crystalline solid known as Sumatra or Borneo camphor. Camphor oil is obtained from incisions in the tree, and has a fragrant, aromatic odor. It has been used for scenting soap. The solid camphor is found in cracks of the wood, and is obtained by cutting down the tree, dividing it into blocks and small pieces, from the interstices of which the camphor is extracted. It differs from the ordinary camphor in being more brittle and not condensing on the sides of the bottle in which it is kept. It is much esteemed by the Chinese, who attribute many virtues to it. It has been long known and is mentioned by Marco Polo in the thirteenth century.

177. DUBOSIA HOPWOODII.—The leaves of this Australian plant are chewed by the natives of Central Australia, just as the Peruvians and Chilians masticate the leaves of the *Erythroxylon coca,* to invigorate themselves during their long foot journeys through the country. They are known as Pitury leaves.

178. DURIO ZIBETHINUS.—A common tree in the Malayan Islands, where its fruit forms a great part of the food of the natives. It is said to have a most delicious flavor combined with a most offensive odor, but when once the repugnance of the peculiar odor is overcome it becomes a general favorite. The unripe fruit is cooked and eaten, and the seeds roasted and used like chestnuts.

179. ELÆIS GUINEENSIS.—The African oil palm is a native of southwestern Africa, but has been introduced into other regions. It grows to a height of 20 to 30

feet and bears dense heads of fruit. The oil is obtained by boiling the fruits in water and skimming off the oil as it rises to the surface. It is used in the manufacture of candles. In Africa it is eaten as butter by the natives.

180. ELÆIS MELANOCOCCA.—A palm from tropical America which produces large quantities of oil.

181. ELÆOCARPUS HINAU.—A New Zealand tree, of the linden family. The bark affords an excellent permanent dye, varying from light brown to deep black. The fruits are surrounded by an edible pulp, and they are frequently pickled like olives.

182. ELETTARIA CARDAMOMUM.—This plant furnishes the fruits known as the Small or Malabar cardamoms of commerce. The seeds are used medicinally for their cordial aromatic properties, which depend upon the presence of a volatile oil. In India the fruits are chewed by the natives with their betel.

183. EMBLICA OFFICINALIS.—A plant belonging to *Euphorbiaceæ*, a native of India. In Borneo the bark and young shoots are used to dye cotton black, for which purpose they are boiled in alum. The fruits are made into sweetmeats, with sugar, or eaten raw, but they are exceedingly acid; when ripe and dry, they are used in medicine, under the name of *Myrobalani emblici*. The natives of Travancore have a notion that the plant imparts a pleasant flavor to water, and therefore place branches of the tree in their wells, especially when the water is charged with an accumulation of impure vegetable matter.

184. ENCKEA UNGUICULATA.—A plant of the family *Piperaceæ*, having an aromatic fruit like a berry, with a thick rind. The roots are used medicinally in Brazil.

185. ENTADA SCANDENS.—This leguminous plant has remarkable pods, which often measure 6 or 8 feet in length. The seeds are about 2 inches across, and half an inch thick, and have a hard, woody, and beautifully polished shell, of a dark-brown or purplish color. These seeds are frequently converted into snuff-boxes and other articles, and in the Indian bazars they are used as weights.

186. ERIODENDRON ANFRACTUOSUM.—The silk-cotton, or God tree of the West Indies. The fruit is a capsule, filled with a beautiful silky fiber, which is very elastic, but can not be woven, and is only used for stuffing cushions.

187. ERYTHRINA CAFFRA.—The Kaffir tree of South Africa. The wood is soft and so light as to be used for floating fishing nets. The scarlet seeds are employed for making necklaces. The Erythrinas, of which there are many species, are mostly remarkable for the brilliant scarlet of their flowers, and are known as Coral trees.

188. ERYTHRINA UMBROSA.—This is a favorite tree for growing in masses, for the purpose of sheltering cocoanut plantations, and inducing a proper degree of moisture in their neighborhood.

189. ERYTHROXYLON COCA.—The leaves of this plant, under the name of coca, are much used by the inhabitants of South America as a masticatory. It forms an article of commerce among the Indians, who carefully dry the leaves and use them daily. Their use, in moderation, acts as a stimulant to the nervous system and enables those who chew them to perform long journeys without any other food. The use of coca in Peru is a very ancient custom, said to have originated with the Incas. It is common throughout the greater part of Peru, Quito, New Granada; and on the banks of the Rio Negro it is known as Spadic. A principle, called *cocaine*, has been extracted from the leaves, which is used in medicine.

190. EUCALYPTUS AMYGDALINA.—The peppermint tree, a native of Tasmania. It produces a thin, transparent oil possessed of a pungent odor resembling oil of lemons, and tasting like camphor, which has great solvent properties. The genus *Eucalyptus* is extensive and valuable. The greater number form large trees, known in Australia as gum trees.

191. EUCALYPTUS GIGANTEA.—This stringy bark gum furnishes a strong, durable timber, used for shipbuilding and other purposes. *E. robusta* contains large cavities in its stem, between the annual concentric circles of wood, filled with a red gum. Many of the species yield gums and astringent principles and also a species of manna. The timber of these trees has been pronounced to be unsurpassed for strength and durability by any other timber known. The leaves of these trees are placed vertically to the sun, a provision suited to a dry and sultry climate.

192. EUCALYPTUS GLOBULUS.—The blue gum, a rapid-growing tree, attaining to a large size. Recently it has attracted attention and gained some repute in medicine as an antiperiodic. The leaves have also been applied to wounds with some success. It produces a strong camphor-smelling oil, which has a mint-like taste, not at all disagreeable.

193. EUGENIA ACRIS.—The wild clove or bayberry tree of the West Indies. In Jamaica it is sometimes called the black cinnamon. The refreshing perfume known as bay rum is prepared by distilling the leaves of this tree with rum. It is stated that the leaves of the allspice are also used in this preparation.

194. EUGENIA JAMBOSA.—A tropical plant, belonging to the myrtle family, which produces a pleasant rose-flavored fruit, known as the Roseapple, or Jamrosade.

195. EUGENIA PIMENTO.—The fruits of this West Indian tree are known in commerce as allspice; the berries have a peculiarly grateful odor and flavor, resembling a combination of cloves, nutmeg, and cinnamon; hence the name of allspice. The leaves when bruised emit a fine aromatic odor, and a delicate odoriferous oil is distilled from them, which is said to be used as oil of cloves. The berries, bruised and distilled with water, yield the pimento oil of commerce.

196. EUGENIA UGNI.—This small-foliaged myrtaceous plant is a native of Chili. It bears a glossy black fruit, which has an agreeable flavor and perfume, and is highly esteemed in its native country. The plant is hardy in the Southern States.

197. EUPHORBIA CANARIENSIS.—This plant grows in abundance in the Canary Islands and Teneriffe, in dry, rocky districts, where little else can grow, and where it attains a height of 10 feet, with the branches spreading 15 or 20 feet. It is one of the kinds that furnish the drug known as *Euphorbium.* The milky juice exudes from incisions made in the branches, and is so acrid that it excoriates the hand when applied to it. As it hardens it falls down in small lumps, and those who collect it are obliged to tie cloths over their mouths and nostrils to exclude the small, dusty particles, as they produce incessant sneezing. As a medicine its action is violent, and it is now rarely employed. There are a vast number of species of *Euphorbia*, varying exceedingly in their general appearance, but all of them having a milky juice which contains active properties. Many of them can scarcely be distinguished from cactuses so far as relates to external appearances, but the milky exudation following a puncture determines their true character. *E. grandidens* is a tall-growing, branching species, and attains a height of 30 feet. The natives of India use the juice of *E. antiquorum*, when diluted, as a purgative. The juice of *E. heptagona* and other African species is employed to poison arrows; the juice of *E. cotinifolia* is used for the same purpose in Brazil. The roots of *E. gerardiana* and *E. pithyusa* are emetic, while *E. thymifolia* and *E. hypericifolia* possess astringent and aromatic properties. The poisonous principle which pervades these plants is more or less dissipated by heat. The juice of *E. cattimandoo* furnishes caoutchouc of a very good quality, which, however, becomes brittle, although soaking in hot water renders it again pliable. *E. phosphorea* derives the name from the fact of its sap emitting a phosphorescent light, on warm nights, in the Brazilian forests.

198. EUTERPE EDULIS.—The assai palm of Para. It grows in swampy lands, and produces a small fruit thinly coated with clotted flesh of which the inhabitants of Para manufacture a beverage called assai. The ripe fruits are soaked in warm water and kneaded until the fleshy pulp is detached. This, when strained, is of a thick, creamy consistence, and, when thickened with cassava farina and sweetened with sugar, forms a nutritious diet, and is the daily food of a large number of the people.

199. EUTERPE MONTANA.—The center portion of the upper part of the stem of this West Indian palm, including the leaf bud, is eaten either when cooked as a vegetable or pickled, but the tree must be destroyed in order to obtain it.

200. EXCŒCARIA SEBIFERA.—This Euphorbiaceous plant is the tallow tree of China. The fruits, are about half an inch in diameter, and each contains three seeds, thickly coated with a fatty substance which yields the tallow. This is obtained by first steaming the seeds, then bruising them to loosen the fat without breaking the seeds, which are removed by sifting. The fat is then made into flat circular cakes and pressed, when the pure tallow ex-

udes in a liquid state and soon hardens into a white, brittle mass. Candles made from this get soft in hot weather, which is prevented by coating them with insect wax. A liquid oil is obtained from the seeds by pressing. The tree yields a hard wood, used by the Chinese for printing blocks, and its leaves are used in dyeing black.

201. EXOGONIUM PURGA.—This plant furnishes the true jalap-tubers of commerce. They owe their well-known purgative properties to their resinous ingredients. Various species of Ipomœa furnish a spurious kind of this drug, which is often put in the market as the genuine article.

202. EXOSTEMMA CARIBÆUM.—This West Indian plant has become naturalized in southern Florida. It belongs to the cinchona family and is known as Jamaica bark. It is also known as Quinquina Caraibe. The bark is reputed to be a good febrifuge, and also to be employed as an emetic. It is supposed to contain some peculiar principle, as the fracture displays an abundance of small crystals. The capsules, before they are ripe, are very bitter, and their juice causes a burning itching on the lips.

203. FERONIA ELEPHANTUM.—The wood apple or elephant apple tree of India, belonging to the family *Aurantiaceæ.* It forms a large tree in Ceylon, and yields a hard, heavy wood, of great strength. It yields a gum, which is mixed with other gums and sold under the name of East Indian gum arabic. The fruit is about the size of an orange, and contains a pulpy flesh, which is edible, and a jelly is made from it, which is used in cases of dysentery. The leaves have an odor like that of anise, and the native India doctors employ them as a stomachic and carminative.

204. FEUILLÆA CORDIFOLIA.—The sequa or cacoon antidote of Jamaica. It belongs to the cucumber family, and climbs to a great height up the trunks of trees. The seeds are employed as a remedy in a variety of diseases, and are considered an antidote against the effects of poison; they also contain a quantity of semisolid fatty oil, which is liberated by pressing and boiling them in water.

205. FICUS ELASTICA.—This plant is known as the india-rubber tree. It is a native of the East Indies, and is the chief source of caoutchouc from that quarter of the globe, although other species of Ficus yield this gum, as well as several plants of other genera. It is a plant of rapid growth, and from the larger branches roots descend to the earth as in the case of the banyan tree.

206. FICUS INDICA.—The famous banyan tree of history. Specimens of this Indian fig are mentioned as being of immense size. One in Bengal spreads over a diameter of 370 feet. Another covered an area of 1,700 square yards. It is one of the sacred trees of the Hindoos. It was known to the ancients. Strabo describes it, and it is mentioned by Pliny. Milton also alludes to it as follows:

> Branching so broad along, that in the ground
> The bending twigs take root; and daughters grow
> About the mother tree; a pillared shade,
> High overarched, with echoing walks between.
> There oft the Indian herdsman, shunning heat,
> Shelters in cool; and tends his pasturing herds
> At loop-holes cut through thickest shade.

207. FICUS RELIGIOSA.—The pippul tree of the Hindoos, which they hold in such veneration that, if a person cuts or lops off any of the branches, he is looked upon with as great abhorrence as if he had broken the leg of one of their equally sacred cows. The seeds are employed by Indian doctors in medicine.

208. FLACOURTIA SEPIARIA.—A bushy shrub, used in India for hedges. Its fruit has a pleasant, subacid flavor when perfectly ripe, but the unripe fruit is extremely astringent. The Indian doctors use a liniment made of the bark in cases of gout, and an infusion of it as a cure for snake bites.

209. FOURCROYA CUBENSE.—This plant is closely related to the agave, and, like many of that genus, furnishes a fine fiber, which is known in St. Domingo as Cabuya fiber. These plants are very magnificent when in flower, throwing up stems 20 to 30 feet in height, covered with many hundreds of yucca-like blossoms.

210. FRANCISCEA UNIFLORA.—A Brazilian plant called Mercurio vegetal; also known as Manaca. The roots, and to some extent the leaves, are used in medicine; the inner bark and all the herbaceous parts are nauseously bitter; it is re-

garded as a purgative, emetic, and alexipharmic; in overdoses it is an acrid poison.

211. Fusanus acuminatus.—A small tree of the Cape of Good Hope and Australia. It bears a globular fruit of the size of a small peach, and is known in Australia as the native peach. It has an edible nut, called the Quandang nut, which is said to be as sweet and palatable as the almond.

212. Galipea officinalis.—This South American tree furnishes Angostura bark, which has important medical properties, some physicians in South America preferring it to cinchona in the treatment of fevers. Its use has been greatly retarded by bark of the deadly nux-vomica tree having been inadvertently sold for it. As this bark is sometimes used in bitters, a mistake, as above, might prove as fatal as cholera.

213. Garcinia mangostana.—This tree produces the tropical fruit called mangosteen, a beautiful fruit, having a thick, succulent rind, which contains an astringent juice, and exudes a gum similar to gamboge. The esculent interior contains a juicy pulp, of the whiteness and solubility of snow, and of a refreshing, delicate, delicious flavor. The bark of the tree is used as a basis for black dye, and it has also some medicinal value.

214. Garcinia morella.—It is supposed that Siam gamboge is obtained from this tree, also that known as Ceylon gamboge. The juice is collected by incising the stems, or by breaking young twigs of the tree and securing the yellow gum resinous exudations in hollow bamboos, where it is allowed to harden. It is employed by artists in water colors and as a varnish for lacquer work.

215. Garcinia pictoria.—A fatty matter known as gamboge butter is procured from the seeds of this tree in Mysore. They are pounded in a stone mortar, then boiled till the butter or oil rises to the surface. It is used as a lamp oil, and sometimes in food.

216. Gardenia florida and gardenia radicans.—Cape Jasmines, so called from a supposition that they were natives of the Cape of Good Hope. The genus belongs to the cinchona family. *G. lucida* furnishes a fragrant resin somewhat similar to myrrh. The fruit of *G. campanulata* is used as a cathartic, and also to wash out stains in silks. *G. gummifera* yields a resin something like Elemi.

217. Gastrolobium bilobium.—A leguminous plant, having poisonous properties. In western Australia, where it is a native, farmers often lose their cattle through their eating the foliage. Cats and dogs that eat the flesh of these poisoned cattle are also poisoned. *G. obtusum* and *G. spinosum* possess similar properties.

218. Genipa americana.—This belongs to the cinchona family, and produces the fruit called genipap or marmalade box. It is about the size of an orange, and has an agreeable flavor. The juice of the fruit yields a bluish-black dye, called Canito or Lana-dye. This color is very permanent, and is much used by Indians in South America.

219. Geonoma schottiana.—A pretty Brazilian palm; the leaves are used for thatching huts, and other parts of the plant are utilized.

220. Gouania domingensis.—A plant of the buckthorn family, known in Jamaica as Chaw-Stick, on account of its thin branches being chewed as an agreeable stomachic. Tooth brushes are made by cutting pieces of the stem to convenient lengths and fraying out the ends. A tooth powder is prepared by pulverizing the dried stems. It is said to possess febrifugal properties, and owing to its pleasant bitter taste it is used for flavoring cooling beverages.

221. Grevillea robusta.—The silk oak tree of Australia; a tree that attains a large size, and is remarkable for the graceful beauty of its foliage.

222. Grewia asiatica.—This Indian tree represents a genus of plants of considerable economic value. This particular species yields a profusion of small red fruits which are used for flavoring drinks, having a pleasant acid flavor. The fibrous inner bark is employed by the natives for making fishing nets, ropes, twine, and for other similar purposes.

223. Grias cauliflora.—The anchovy pear of Jamaica. The fruit is pickled and eaten like the mango, having a similar taste.

224. Guaiacum officinale.—The wood of this tree is called Lignum Vitæ. A resin, called gum guaiacum, exudes from the stem, and is otherwise obtained from the wood by artificial means. It is of a greenish-brown color,

with a balsamic fragrance, and is remarkable for the changes of color it undergoes when brought into contact with various substances. Gluten gives it a blue tint; nitric acid and chlorin change it successively to green, blue, and brown. The resin is used medicinally as also are the bark and wood.

225. GUAZUMA TOMENTOSA.—This plant is nearly allied to the chocolate-nut tree, and yields fruits that abound in mucilage, as also does the bark of the young shoots. The mucilage is given out in water, and has been used as a substitute for gelatin or albumen in clarifying cane juice in the manufacture of sugar. The timber is light, and is employed for the staves of sugar hogsheads; it is known in Jamaica as bastard cedar. A strong fiber is obtained from the young shoots.

226. GUILIELMA SPECIOSA.—The peach palm of Venezuela. The fruits are borne in large drooping bunches, and their fleshy outer portion contains starchy matter, which forms a portion of the food of the natives. They are cooked and eaten with salt, and are said to resemble a potato in flavor. A beverage is prepared by fermenting them in water, and the meal obtained from them is made into bread. The wood of the old trees is black, and so hard as to turn the edge of an ax.

227. HÆMATOXYLON CAMPECHIANUM.—The logwood tree. This dyestuff is largely used by calico printers and other dyeing manufacturers. It is also used as an ingredient in some writing inks. The heart wood is the part used for dyeing. This is cut into chips which yield their color to water and alcohol. The colors are various according to treatment, giving violet, yellow, purple, and blue, but the consumption of logwood is for black colors, which are obtained by alum and iron bases.

228. HARDENBERGIA MONOPHYLLA.—An Australian climbing plant of the leguminous family. The long, carrot-shaped, woody root was called, by the early settlers in that country, sarsaparilla, and is still used in infusion as a substitute for that root.

229. HARTIGHSEA SPECTABILIS.—A New Zealand tree, called Wahahe by the natives, who employ the leaves as a substitute for hops, and also prepare from them a spirituous infusion as a stomachic medicine.

230. HELICONIA BIHAI.—A plant of the order *Musaceæ*, from South America. The young shoots are eaten by the natives, and the fruits are also collected and used as food. It also furnishes a useful fiber.

231. HEVEA BRASILIENSIS.—A tree of tropical America growing in damp forests, especially in the Amazon valley, which, together with other trees called siphonia furnish the Para rubber, or American caoutchouc. The sap is collected from incisions made in the tree during the dry season, and is poured over clay molds and dried by gentle heat, successive pourings being made till a sufficiently thick layer is produced.

232. HIBISCUS ROSA SINENSIS.—The flowers of this malvaceous plant contain a quantity of astringent juice, and, when bruised, rapidly turn black or deep purple; they are used by the Chinese ladies for dyeing their hair and eyebrows, and in Java for blacking shoes.

233. HIBISCUS SABDARIFFA.—This species is known in the West Indies as red sorrel, on account of the calyxes and capsules having an acid taste. They are made into cooling drinks, by sweetening and fermentation. The bark contains a strong useful fiber which makes good ropes if not too much twisted. It is also known as the Roselee plant.

234. HIBISCUS TILIACEUS.—A plant common to many tropical countries. Its wood is extremely light when dry, and is employed by the Polynesians for getting fire by friction, which is said to be a very tedious and tiresome operation, and difficult to accomplish. Good fiber is also obtained from the bark.

235. HIPPOMANE MANCINELLA.—This is the poisonous manchineel tree of South America and other tropical regoins. The virulent nature of the juice of this tree has given it a reputation equal to that forced upon the upas tree of Java. The juice is certainly very acrid, and even its smoke, when burning, causes temporary blindness. The fruit is equally dangerous, and from its beautiful appearance is sometimes partaken of by those who are unaware of its deleterious properties, but its burning effects on the lips soon causes them to desist. Indians are said to poison their arrows with the juice of this tree.

236. HURA CREPITANS.—This tropical plant is known as the sand-box tree. Its deep-furrowed, rounded, hard-shelled fruit is about the size of an orange, and when ripe and dry, it bursts open with a sharp noise like the report of

a pistol; hence, it is also called the monkey's dinner bell. An emetic oil is extracted from the seeds, and a venomous, milky juice is abundant in all parts of the plant.

237 .HYMENÆA COURBARIL.—The locust tree of the West Indies; also called algarroba in tropical regions. This is one of the very largest growing trees known, and living trees in Brazil are supposed to have been growing at the commencement of the Christian era. The timber is very hard, and is much used for building purposes. A valuable resin, resembling the anime of Africa, exudes from the trunk, and large lumps of it are found about the roots of old trees.

238. HYPHÆ THEBAICA.—The doum, or doom palm, or gingerbread of Egypt; it grows also in Nubia, Abyssinia, and Arabia. The fibrous, mealy husks of the seeds are eaten, and taste almost like gingerbread. In the Thebias this palm forms extensive forests, the roots spreading over the lurid ruins of one of the largest and most splendid cities of the ancient world.

239. ICICA HEPTAPHYLLA.—The incense tree of Guiana, a tall-growing tree, furnishing wood of great durability. It is called cedar wood on account of its fragrant odor. The balsam from the trunk is highly odoriferous, and used in perfumery, and is known as balsam of acouchi; it is used in medicine. The balsam and branches are burned as incense in churches.

240. ILEX PARAGUAYENSIS.—This is the tea plant of South America, where it occupies the same important position in the domestic economy of the country as the Chinese tea does in this. The *maté* is prepared by drying and roasting the leaves, which are then reduced to a powder and made into packages. When used, a small portion of the powder is placed in a vessel, sugar is added, and boiling water poured over the whole. It has an agreeable, slightly aromatic odor, rather bitter to the taste, but very refreshing and invigorating to the human frame after severe fatigue. It acts in some degree as an aperient and diuretic, and in overdoses produces intoxication. It contains the same active principle, theine as tea and coffee, but not their volatile and empyreumatic oils.

241. ILLICIUM ANISATUM.—This magnoliaceous plant is a native of China, and its fruit furnishes the star anise of commerce. In China, Japan, and India it is used as a condiment in the preparation of food, and is chewed to promote digestion, and the native physicians prescribe it as a carminative. It is the flavoring ingredient of the preparation *Anisette de Bordeaux*. Its flavor and odor are due to a volatile oil, which is extracted by distillation, and sold as oil of anise, which is really a different article.

242. ILLICIUM FLORIDANUM.—A native of the Southern States. The leaves are said to be poisonous; hence, the plant is sometimes called poison bag. The bark has been used as a substitute for cascarilla.

243. ILLICIUM RELIGIOSUM.—A Japanese species, which reaches the size of a small tree, and is held sacred by the Japanese, who form wreaths of it with which to decorate the tombs of their deceased friends, and they also burn the fragrant bark as incense. Their watchmen use the powdered bark for burning in graduated tubes, in order to mark the time, as it consumes slowly and uniformly. The leaves are said to possess poisonous properties.

244. INDIGOFERA TINCTORIA.—The indigo plant, a native of Asia, but cultivated and naturalized in many countries. The use of indigo as a dye is of great antiquity. Both Dioscorides and Pliny mention it, and it is supposed to have been employed by the ancient Egyptians. The indigo of commerce is prepared by throwing the fresh cut plants into water, where they are steeped for twelve hours, when the water is run off into a vessel and agitated in order to promote the formation of the blue coloring matter, which does not exist ready formed in the tissues of the plant, but is the result of the oxidation of other substances contained in them. The coloring matter then settles at the bottom; it is then boiled to a certain consistency and afterwards spread out on cloth frames, where it is further drained of water and pressed into cubes or cakes for market.

245. IPOMÆA PURGA.—A species of jalap is obtained from this convolvulaceous plant; this is a resinous matter contained in the juices.

246. IRIARTELLA SETIGERA.—A South American palm growing in the underwood of the forests on the Amazon and Rio Negro. The Indians use its slender stems for making their blow pipes or gravatanas, through which they blow small poisoned arrows with accuracy to a considerable distance.

247. JAMBOSA MALACCENSIS.—This Indian plant belongs to the myrtle family. It produces a good-sized edible fruit known as the Malay apple.

248. JASMINUM SAMBAC TRIFOLIATUM.—A native of South America. The flowers are very fragrant, and an essential oil, much used in perfumery under the name of jasmine oil, is obtained from this and other species.

249. JATROPHA CLAUCA.—An East Indian plant the seeds of which when crushed furnish an oil which is used in medicine.

250. JATROPHA CURCAS.—The physic nut tree of tropical America. This plant contains a milky, acrid, glutinous juice, which forms a permanent stain when dropped on linen, and which might form a good marking ink. Burning oil is expressed from the seeds in the Philippine Islands; the oil, boiled with oxide of iron, is used in China as a varnish. It is used in medicine in various ways, the leaves for fomentations, the juice in treating ulcers, and the seeds as purgatives.

251. JUBÆA SPECTABILIS.—The coquito palm of Chili. The seed or nut is called cokernut, and has a pleasant, nutty taste. These are used by the Chilian confectioners in the preparation of sweetmeats, and by the boys as marbles, being in shape and size like them. The leaves are used for thatching, and the trunks or stems are hollowed out and converted into water pipes. A sirup called Miel de Palma or palm honey, is prepared by boiling the sap of this tree to the consistency of treacle, and is much esteemed for domestic use as sugar. The sap is obtained by cutting off the crown of leaves when it immediately begins to flow and continues for several months provided a thin slice is shaved off the top every morning. Full-grown trees will thus yield 90 gallons.

252. KÆMPFERIA GALANGA.—This plant belongs to the family of gingers. The root stocks have an aromatic fragrance and are used medicinally in India as well as in the preparation of perfumery. The flowers appear before the leaves upon very short stems.

253. KIGELIA PINNATA.—This plant is interesting from the circumstance of its being held sacred in Nubia, where the inhabitants celebrate their religious festivals under it by moonlight, and poles made of its wood are erected as symbols of special veneration before the houses of their great chiefs. The fruits, which are very large, when cut in half and slightly roasted, are employed as an outward application to relieve pains.

254. KRAMERIA TRIANDRIA.—This is one of the species that yield the rhatany roots of commerce. In Peru an extract is made from this species, which is a mild, easily assimilated, astringent medicine. It acts as a tonic, and is used in intermittent and putrid fevers. It is also styptic, and when applied in plasters is used in curing ulcers. The color of the infusion of the roots is blood-red, on which account it is used to adulterate, or rather it forms an ingredient in the fabrication of port wine.

255. KYDIA CALYCINA.—An Indian plant of the family *Byttneriaceæ*. The bark is employed in infusion as a sudorific and in cutaneous diseases, and its fibrous tissue is manufactured into cordage.

256. LAGETTA LINTEARIA.—The lace-bark tree of Jamaica. The inner bark consists of numerous concentric layers of fibers, which interlace in all directions, and thus present a great resemblance to lace. Articles of apparel are made of it. Caps, ruffles, and even complete suits of lace are made with it. It bears washing with common soap, and when bleached in the sun acquires a degree of whiteness equal to the best artificial lace. Ropes made of it are very durable and strong.

257. LANSIUM DOMESTICUM.—A low-growing tree of the East Indies, which is cultivated to some extent for its fruit, which is known in Java and Malacca as lanseh fruit, and is much esteemed for its delicate aroma; the pulp is of somewhat firm consistence and contains a cooling, refreshing juice.

258. LAPAGERIA ROSEA.—A twining plant from Chili. The flowers are very beautiful, and are succeeded by berries, which are said to be sweet and eatable. The root has qualities closely resembling sarsaparilla and used for the same purpose.

259. LATANIA RUBRA.—A very beautiful palm from the Mauritius. The fruit contains a small quantity of pulp, which is eaten by the natives, but is not considered very palatable by travelers.

260. LAWSONIA INERMIS.—This is the celebrated henna of the East. The use of the powdered leaves as a cosmetic is very general in Asia and northern Africa,

the practice having descended from very remote ages, as is proved by the Egyptian mummies, the parts dyed being usually the finger and toe nails, the tips of the fingers, the palms of the hands, and soles of the feet, receiving a reddish color, considered by Oriental belles as highly ornamental. Henna is prepared by reducing the leaves to powder, and when used is made into a pasty mass with water and spread on the part to be dyed, being allowed to remain for twelve hours. The plant is known in the West Indies as Jamaica Mignonette.

261. LECYTHIS OLLARIA.—This tree produces the hard urn-shaped fruits known in Brazil as monkey cups. The seeds are eatable and sold as Sapucaia nuts. The fruit vessels are very peculiar, being 6 inches in diameter and having closely fitting lids, which separate when the seeds are mature. The bark is composed of a great number of layers, not thicker than writing paper, which the Indians separate and employ as cigar wrappers.

262. LEPTOSPERUM LANIGERUM.—A plant known throughout Australia as Captain Cook's tea tree, from the circumstance that, on the first landing of this navigator in that country, he employed a decoction of the leaves of this plant as a corrective to the effects of scurvy among his crew, and this proved an efficient medicine. Thickets of this plant, along the swampy margin of streams, are known as Tea-tree scrubs. It is also known among the natives as the Manuka plant. The wood is hard and heavy, and was formerly used for making sharp-pointed spears. It belongs to the myrtle family of plants.

263. LICUALA ACUTIFIDA.—This palm is a native of the island of Pulo-Penango, and yields canes known by the curious name of Penang Lawyers. It is a low-growing plant, its stems averaging an inch in diameter. The stems are converted into walking canes by scraping their rough exteriors and straightening them by means of fire heat.

264. LIMONIA ACIDISSIMA.—An East India shrub which produces round fruits about the size of damson plums, of a yellowish color, with reddish or purplish tints. They are extremely acid, and the pulp is employed in Java as a substitute for soap.

265. LIVISTONIA AUSTRALIS.—This is one of the few palms found in Australia. The unexpanded leaves, prepared by being scalded and dried in the shade, are used for making hats, while the still younger and more tender leaves are eaten like cabbage.

266. LUCUMA MAMMOSUM.—This sapotaceous plant is cultivated for its fruit, which is called marmalade, on account of its containing a thick agreeably flavored pulp, bearing some resemblance in appearance and taste to quince marmalade. A native of South America.

267. MABA GEMINATA.—The ebony wood of Queensland. The heart wood is black, and the outside wood of a bright red color. It is close-grained, hard, heavy, elastic and tough, and takes a high polish.

268. MACADAMIA TERNIFOLIA.—An Australian tree which produces an edible nut called the Queensland nut. This fruit is about the size of a walnut, and contains within a thick pericarp, a smooth brown-colored nut, inclosing a kernel of a rich and agreeable flavor, resembling in some degree that of a filbert.

269. MACHÆRUM FIRMUM.—A South American tree which furnishes a portion of the rosewood of commerce. Various species of the genus, under the common Brazilian name of Jaccaranda, are said to yield this wood, but there is some uncertainty about the origin of the various commercial rosewoods.

270. MACLURA TINCTORIA.—The fustic tree. Large quantities of the bright yellow wood of this tree are exported from South America for the use of dyers, who obtain from it shades of yellow, brown, olive, and green. A concentrated decoction of the wood deposits, on cooling, a yellow crystalline matter called Morine. This tree is sometimes called old fustic, in order to distinguish it from another commercial dye called young fustic, which is obtained in Europe from a species of Rhus.

271. MACROPIPER METHYSTICUM.—A plant of the pepper family, which furnishes the root called Ava by the Polynesians. It has narcotic properties, and is employed medicinally, but is chiefly remarkable for the value attached to it as a narcotic and stimulant beverage, of which the natives partake before they commence any important business or religious rites. It is used by chewing the root and extracting the juice, and has a calming rather than an intoxicating effect. It is a filthy preparation, and only partaken of by the lower classes of Feejeeans.

272. MACROZAMIA DENISONII.—An Australian cycad, the seeds of which contain a large amount of farina, or starchy matter, which formerly supplied a considerable amount of food for the natives of that country. The fresh seeds are very acrid, but when steeped in water and roasted they become palatable and nutritious.

273. MALPIGHIA GLABRA.—A low-growing tree of the West Indies, which produces an edible fruit called the Barbadoes cherry.

274. MAMMEA AMERICANA.—The fruit of this tree, under the name of mammee apple, is very much esteemed in tropical countries. It often attains a size of 6 or 8 inches in diameter and is of a yellow color. The outer rind and the pulp which immediately surrounds the seeds are very bitter, but the intermediate is sweet and aromatic. The seeds are used as anthelmintics, an aromatic liquor is distilled from the flowers, and the acrid, resinous gum distilled from the bark is used to destroy insects.

275. MANETTIA CORDIFOLIA.—This climbing-plant is a native of South America, and belongs to the family of *Cinchonaceæ*. The rind of the root has emetic properties, and is used in Brazil for dropsy and other diseases. It is also exported under the name of Ipecacuan, chiefly from Buenos Ayres.

276. MANGIFERA INDICA.—The mango, in some of its varieties esteemed as the most delicious of tropical fruits, while many varieties produce fruit whose texture resembles cotton and tastes of turpentine. The unripe fruit is pickled. The pulp contains gallic and citric acid. The seeds possess anthelmintic properties. A soft gum resin exudes from the wounded bark, which is used medicinally.

277. MANICARIA SACCIFERA.—Bussu palm of South America. Its large leaves are used for thatching roofs, for which purpose they are well fitted and very durable. The fibrous spathe furnishes a material of much value to the natives. This fibrous matter when taken off entire is at once converted into capital bags, in which the Indian keeps the red paint for his toilet, or the silk cotton for his arrows, or he stretches out the larger ones to make himself a cap of nature's own weaving, without seam or joint.

278. MANIHOT UTILISSIMA.—This euphorbiaceous plant yields cassava or mandiocca meal. It is extensively cultivated in tropical climates and supplies a great amount of food. The root is the part used, and in its natural condition is a most virulent poison, but by grating the roots to a pulp the poison is expelled by pressure, and altogether dissipated by cooking. The expressed juice, when allowed to settle, deposits the starch known as tapioca.

279. MARANTA ARUNDINACEA.—The arrowroot plant, cultivated for its starch. The tubers being reduced to pulp with water, the fecula subsides, and is washed and dried for commerce. It is a very pure kind of starch, and very nutritious. The term arrowroot is said to be derived from the fact that the natives of the West Indies use the roots of the plant as an application to wounds made by poison arrows.

280. MAURITIA FLEXUOSA.—The Moriche, or Ita palm, very abundant on the banks of the Amazon, Rio Negro, and Orinoco Rivers. In the delta of the latter it occupies swampy tracts of ground, which are at times completely inundated, and present the appearance of forests rising out of the water. These swamps are frequented by a tribe of Indians called Guaranes, who subsist almost entirely upon the produce of this palm, and during the period of the inundations suspend their dwellings from the tops of its tall stems. The outer skin of the young leaves is made into string and cord for the manufacture of hammocks. The fermented sap yields palm wine, and another beverage is prepared from the young fruits, while the soft inner bark of the stem yields a farinaceous substance like sago.

281. MAXIMILIANA REGIA.—An Amazonian palm called Inaja. The spathes are so hard that, when filled with water, they will stand the fire, and are sometimes used by the Indians as cooking utensils. The Indians who prepare the kind of rubber called bottle rubber, make use of the hard stones of the fruit as fuel for smoking and drying the successive layers of milky juice as it is applied to the mold upon which the bottles are formed. The outer husk, also, yields a kind of saline flour used for seasoning their food.

282. MELALEUCA MINOR.—A native of Australia and the islands of the Indian Ocean. The leaves, being fermented, are distilled, and yield an oil known as cajuput or cajeput oil, which is green, and has a strong aromatic odor. It is

valuable as an antispasmodic and stimulant, and at one time had a great reputation as a cure for cholera. In China the leaves are used as a tonic in the form of decoction.

283. MELICOCCA BIJUGA.—This sapindaceous tree is plentiful in tropical America and the West Indies, and is known as the Genip tree. It produces numerous green egg-shaped fruits, an inch in length, possessing an agreeable vinous and somewhat aromatic flavor, called honey berries or bullace plums. The wood of the tree is hard and heavy.

284. MELOCACTUS COMMUNIS.—Commonly called the Turk's Cap cactus, from the flowering portion on the top of the plant being of a cylindrical form and red color, like a fez cap. Notwithstanding that they grow in the most dry sterile places, they contain a considerable quantity of moisture, which is well known to mules, who resort to them when very thirsty, first removing the prickles with their feet.

285. MESEMBRYANTHEMUM CRYSTALLINUM.—The ice plant, so called in consequence of every part of the plant being covered with small watery pustules, which glisten in the sun like fragments of ice. Large quantities of this plant are collected in the Canaries and burned, the ashes being sent to Spain for the use of glass makers. *M. edule* is called the Hottentot's fig, its fruit being about the size of a small fig, and having a pleasant, acid taste when ripe. *M. tortuosum* possesses narcotic properties, and is chewed by the Hottentots to induce intoxication. The fruits possess hygrometric properties, the dried, shriveled, capsules swelling out and opening so as to allow of the escape of the seeds when moistened by rain, which at the same time fits the soil for their germination.

286. MIKANIA GUACO.—A composite plant which has gained some notoriety as the supposed Cundurango, the cancer-curing bark. It has long been supposed to supply a powerful antidote for the bite of venomous serpents.

287. MIMUSOPS BALATA.—The Bully tree. This sapotaceous plant attains a great size in Guiana and affords a dense, close-grained, valuable timber. Its small fruits, about the size of coffee berries, are delicious when ripe. The flowers also yield a perfume when distilled in water, and oil is expressed from the seeds.

288. MIMUSOPS ELENGI.—A native of Ceylon, where its hard, heavy, durable timber is used for building purposes. The seed also affords a great amount of oil.

289. MONODORA GRANDIFLORA.—An African plant belonging to the Anonaceæ. It produces large fruit, which contains a large quantity of seeds about the size of the Scarlet-Runner bean. They are aromatic and impart to the fruit the odor and flavor of nutmeg; hence they are also known as calabash nutmegs.

290. MONSTERA DELLCIOSA.—This is a native of southern Mexico and yields a delicious fruit with luscious pineapple flavor. The outer skin of the fruit, if eaten, causes a stinging sensation in the mouth. This is easily removed when the fruit is ripe. The leaves are singularly perforated with holes at irregular intervals, from natural causes not sufficiently explained. In Trinidad the plant is called the Ceriman.

291. MORINGA PTERYGOSPERMA.—A native of the East Indies, where it bears the name of horse-radish tree. The seeds are called ben nuts and supply a fluid oil, highly prized by watchmakers, called oil of ben. The root is pungent and stimulant and tastes like horse-radish.

292. MORONOBEA COCCINEA.—The hog gum tree, which attains the height of 100 feet. A fluid juice exudes from incisions in the trunk and hardens into a yellow resin. It is said the hogs in Jamaica when wounded rub the injured part against the tree so as to cover it with the gum, which possesses vulnerary properties; hence its name. The resin has been employed as a substitute for copaiba balsam, and plasters are made of it.

293. MUCUNA PRURIENS.—A tall climbing plant of the West Indies and other warm climates. It is called the cowage, or cow-itch, on account of the seed pods being covered with short brittle hairs, the points of which are finely serrated, causing an unbearable itching when applied to the skin, which is relieved by rubbing the part with oil. It is employed as a vermifuge. In East Africa it is called Kitedzi. The sea beans found on the coast of Florida are the seeds of Mucuna altissima. In Cuba these are called bulls' eyes.

294. MURRAYA EXOTICA.—A Chinese plant of the orange family. The fruit is succulent, and the white flowers are very fragrant. They are used in perfumery.

295. MUSA CAVENDISHII.—This is a valuable dwarf species of the banana from southern China. It bears a large truss of fine fruit, and is cultivated to some extent in Florida, where it endures more cold than the West India species and fruits more abundantly.

296. MUSA ENSETE.—This Abyssinian species forms large foliage of striking beauty. The food is dry and uneatable; but the base of the flower stalk is eaten by the natives.

297. MUSA SAPIENTUM.—The banana plant. This has been cultivated and used as food in tropical countries from very remote times, and furnishes enormous quantities of nutritious food, and serves as a staple support to a large number of the human race. The expressed juice is in some countries made into a fermented liquor and the young shoots eaten as a vegetable.

298. MUSA TEXTILIS.—This furnishes the fiber known as manilla hemp, and is cultivated in the Philippine Islands for this product. The finer kinds of the fiber are woven into beautiful shawls and the coarser manufactured into cordage for ships. The fiber is obtained from the leaf-stalks.

299. MUSSÆNDA FRONDOSA.—This cinchonaceous plant is a native of Ceylon. The bark and leaves are esteemed as tonic and ferbrifuges in the Mauritius, where they are known as wild cinchona. The leaves and flowers are also used as expectorants, and the juice of the fruit and leaves is used as an eyewash.

300. MYRISTICA MOSCHATA.—The nutmeg tree. The seed of this plant is the nutmeg of commerce, and mace is the seed cover of the same. When the nuts are gathered they are dried and the outer shell of the seed removed. The mace is also dried in the sun and assumes a golden yellow color. The most esteemed nutmegs come from Penang. At one time the nutmeg culture was monopolized by the Dutch, who were in the habit of burning them when the crop was too abundant, in order to keep up high prices.

301. MYROSPERMUM PERUIFERUM.—This plant yields the drug known as balsam of Peru, which is procured by making incisions in the bark, into which cotton rags are thrust; a fire is then made round the tree to liquefy the balsam. The balsam is collected by boiling the saturated rags in water. It is a thick, treacly looking liquid, with fragrant aromatic smell and taste, and is not used so much in medicine as it formerly was.

302. MYROSPERUM TOLUIFERUM.—A South American tree, also called Myroxylon, which yields the resinous drug called balsam of Tolu. This substance is fragrant, having a warm, sweetish taste, and burns with an agreeable odor. It is used in perfumery and in the manufacture of pastiles, also for flavoring confectionery, as in Tolu lozenges.

303. MYRTUS COMMUNIS—The common myrtle. This plant is supposed to be a native of western Asia, but now grows abundantly in Italy, Spain, and the south of France. Among the ancients the myrtle was held sacred to Venus and was a plant of considerable importance, wreaths of it being worn by the victors of the Olympic games and other honored personages. Various parts of the plant were used in medicine, in cookery, and by the Tuscans in the preparation of myrtle wine, called *myrtidanum*. It is still used in perfumery, and a highly perfumed distillation is made from the flowers. The fruits are very aromatic and sweet, and are eaten fresh or dried and used as a condiment.

304. NANDINA DOMESTICA.—A shrub belonging to the family of berberries. It is a native of China and Japan, where it is extensively cultivated for its fruits. It is there known as Nandin.

305. NAUCLEA GAMBIR.—A native of the Malayan Islands, which yields the Gambir, or Terra Japonica of commerce. This is prepared by boiling the leaves in water until the decoction thickens, when it is poured into molds, where it remains until it acquires the consistency of clay; it is then cut into cubes and thoroughly dried. It is used as a masticatory in combination with the areca nut and betel leaf, and also for tanning purposes.

306. NECTANDRA LEUCANTHA.—The greenheart, or bibiru tree of British Guiana, furnishing bibiru bark, which is used medicinally as a tonic and febrifuge, its properties being due to the presence of an uncrystallizable alkaloid, also found in the seeds. The seeds are also remarkable for containing

upwards of 50 per cent of starch, which is made into a kind of bread by the natives. The timber of this tree is extensively employed in shipbuilding, its great strength and durability rendering it peculiarly well suited for this purpose.

307. NEPENTHES DISTILLATORIA.—This pitcher plant is a native of Ceylon. The pitchers are partly filled with water before they open; hence it was supposed to be produced by some distilling process. In Ceylon the old, tough, flexible stems are used as willows.

308. NEPHELIUM LITCHI.—This sapindaceous tree produces one of the valued indigenous fruits of China. There are several varieties; the fruit is round, about an inch and a half in diameter, with a reddish-colored, thin, brittle shell. When fresh they are filled with a sweet, white, transparent, jelly-like pulp. The Chinese are very fond of these fruits and consume large quantities of them, both in the fresh state and when dried and preserved.

309. NERIUM OLEANDER.—This is a well-known plant, often seen in cultivation, and seemingly a favorite with many. It belongs to a poisonous family and is a dangerous poison. A decoction of its leaves forms a wash, employed in the south of Europe to destroy vermin; and its powdered wood and bark constitute the basis of an efficacious rat-poison. Children have died from eating the flowers. A party of soldiers in Spain, having meat to roast in camp, procured spits and skewers of the tree, which there attains a large size. The wood having been stripped of its bark, and brought in contact with the meat, was productive of fatal consequences, for seven men died out of the twelve who partook of the meat and the other five were for some time dangerously ill.

310. NOTELÆA LIGUSTRINA.—The Tasmanian ironwood tree. It is of medium growth and furnishes wood that is extremely hard and dense, and used for making sheaves for ships' blocks, and for other articles that require to be of great strength. The plant belongs to the olive family.

311. OCHROMA LAGOPUS.—A tree that grows about 40 feet high, along the seashores in the West Indies and Central America, and known as the cork wood. The wood is soft, spongy, and exceedingly light, and is used as a substitute for cork, both in stopping bottles and as floats for fishing nets. It is also known as Balsa.

312. ŒNOCARPUS BATAVA.—A South American palm, which yields a colorless, sweet-tasted oil, used in Para for adulterating olive oil, being nearly as good for this purpose as peanut oil, so largely used in Europe. A palatable but slightly aperient beverage is prepared by triturating the fruits in water, and adding sugar and mandiocca flour.

313. OLEA EUROPÆA.—The European olive, which is popularly supposed to furnish *all* the olive oil of commerce. It is a plant of slow growth and of as slow decay. It is considered probable that trees at present existing in the Vale of Gethsemane are those which existed at the commencement of the Christian era. The oil is derived from the flesh of the fruit, and is pressed out of the bruised pulp; inferior kinds are from second and third pressings. The best salad oil is from Leghorn, and is sent in flasks surrounded by rush-work. Gallipoli oil is transported in casks, and Lucca in jars. The pickling olives are the unripe fruits deprived of a portion of their bitterness by soaking in water in which lime and wood ashes are sometimes added, and then bottled in salt and water with aromatics.

314. OPHIOCARYON PARADOXUM.—The snake nut tree of Guiana, so called on account of the curious form of the embryo of the seed, which is spirally twisted, so as to closely resemble a coiled-up blacksnake. The fruits are as large as those of the black walnut, and although they are not known to possess any medical properties, their singular snake-like form has induced the Indians to employ them as an antidote to the poison of venomous snakes. The plant belongs to the order of *Sapindaceæ*.

315. OPHIORHIZA MUNGOS.—A plant belonging to the cinchona family, the roots of which are reputed to cure snake bites. They are intensely bitter, and from this circumstance they are called earth-galls by the Malays.

316. OPHIOXYLON SERPENTINUM.—A native of the East Indies, where the roots are used in medicine as a febrifuge and alexipharmic.

317. OPUNTIA COCHINELLIFERA.—A native of Mexico, where it is largely cultivated in what are called the Nopal plantations for the breeding of the cochineal insect. This plant and others are also grown for a similar purpose in the

Canary Islands and Madeira. Some of these plantations contain fifty thousand plants. Cochineal forms the finest carmine scarlet dye, and at least there are 2,000 tons of it produced yearly, in value worth $2,000 per ton.

318. OPUNTIA TUNA.—This plant is a native of Mexico and South America generally. It reaches a height of 15 to 20 feet and bears reddish-colored flowers, followed by pear-shaped fleshy fruits 2 or 3 inches long, and of a rich carmine color when ripe. It is cultivated for rearing the cochineal insect. The fruits are sweet and juicy; sugar has been made from them. The juice is used as a water-color and for coloring confectionery.

319. OREODAPHNE CALIFORNICA.—The mountain laurel, or spice bush, of California. When bruised it emits a strong, spicy odor, and the Spanish Americans use the leaves as a condiment.

320. OREODOXA OLERACEA.—The West Indian cabbage palm, which sometimes attains the height of 170 feet, with a straight cylindrical trunk. The semicylindrical portions of the leaf-stalk are formed into cradles for children, or made into splints for fractures. Their inside skin, peeled off while green, and dried, looks like vellum, and can be written upon. The heart of young leaves, or cabbage, is boiled as a vegetable or pickled, and the pith affords sago. Oil is obtained from the fruit.

321. ORMOSIA DASYCARPA.—This is the West Indian bead tree, or necklace tree, the seeds of which are roundish, beautifully polished, and of a bright scarlet color, with a black spot at one end resembling beads, for which they are substitutes, being made into necklaces, bracelets, or mounted in silver for studs and buttons. It is a leguminose plant.

322. OSMANTHUS FRAGRANS.—This plant has long heen cultivated as Olea Fragrans. The flowers have a fine fragrance, and are used by the Chinese to perfume tea. It appears that they consider the leaves also valuable, for they are frequently found in what is expected to be genuine tea.

323. PACHIRA ALBA.—A South American tree the inner bark of which furnishes a strong useful fiber, employed in the manufacture of ropes and various kinds of cordage. The petals of the flowers are covered with a soft silky down which is used for stuffing cushions and pillows.

324. PANDANUS UTILIS.—The screw pine of the Mauritius, where it is largely cultivated for its leaves, which are manufactured into bags or sacks for the exportation of sugar. They are also used for making other domestic vessels and for tying purposes.

325. PAPPEA CAPENSIS.—A small tree of the soapberry or sapindaceous family, a native of the Cape of Good Hope, where the fruit is known as the wild plum, from the pulp of which a vinous beverage and excellent vinegar are prepared, and an eatable, though slightly purgative, oil is extracted from the seeds. The oil is also strongly recommended for baldness and scalp affections.

326. PAPYRUS ANTIQUORUM.—The paper-reed of Asia, which yielded the substances used as paper by the ancient Egyptians. The underground root-stocks spread horizontally under the muddy soil, continuing to throw up stems as they creep along. The paper was made from thin slices, cut vertically from the apex to the base of the stem, between its surface and center. The slices were placed side by side, according to the size required, and then, after being wetted and beaten with a wooden instrument until smooth, were pressed and dried in the sun.

327. PARITIUM ELATUM.—The mountain mahoe, a malvaceous plant, that furnishes the beautiful lace-like bark called Cuba bast, imported by nurserymen for tying their plants. It was at one time only seen as employed in tying together bundles of genuine Havana cigars. It forms a tree 40 feet or more in height, and yields a greenish-blue timber, highly prized by cabinet-makers.

328. PARKIA AFRICANA.—The African locust tree, producing seeds which the natives of Soudan roast, and then bruise and allow to ferment in water until they become putrid, when they are carefully washed, pounded into powder, and made into cakes, which are said to be excellent, though having a very unpleasant smell. The pulp surrounding the seeds is made into a sweet farinaceous preparation.

329. PARKINSONIA ACULEATA.—This leguminous plant is called Jerusalem Thorn. Although a native of Southern Texas and Mexico, it is found in many tropical countries, and is frequently used for making hedges. Indians in Mexico employ it as a febrifuge and sudorific and also as a remedy for epilepsy.

330. PARMENTIERA CEREIFERA.—In the Isthmus of Panama this plant is termed the Candle tree, because its fruits, often 4 feet long, look like yellow candles suspended from the branches. They have a peculiar, apple-like smell, and cattle that partake of the leaves or fruit have the smell communicated to the beef if killed immediately.

331. PASSIFLORA QUADRANGULARIS.—The fruit of this plant is the Granadilla of the tropics. The pulp has an agreeable though rather mawkish taste. The root is said to possess narcotic properties, and is used in the Mauritius as an emetic.

332. PAULLINIA SORBILIS.—The seeds of this climbing sapindaceous plant furnish the famous guarana of the Amazon and its principal tributaries. The ripe seeds, when thoroughly dried, are pounded into a fine powder, which made into dough with water, is formed into cylindrical rolls, from 5 to 8 inches long, becoming very hard when dry. It is used as a beverage, which is prepared by grating about half a teaspoonful of one of the cakes into about a teacup of water. It is much used by Brazilian miners, and is considered a preventive of all manner of diseases. It is also used by travelers, who supply themselves with it previous to undertaking lengthy or fatiguing journeys. Its active principle is identical with theine, of which it contains a larger quantity than exists in any other known plant, being more than double that contained in the best black tea.

333. PAVETTA BORBONICA.—This belongs to the quinine family. The roots are bitter, and are employed as a purgative; the leaves are also used medicinally.

334. PEDILANTHUS TITHYMALOIDES.—This euphorbiaceous plant has an acrid, milky, bitter juice; the root is emetic, and the dried branches are used medicinally.

335. PERESKIA ACULEATA.—The Barbadoes gooseberry, which belongs to the family *Cactaceæ.* It grows about 15 feet in height, and produces yellow-colored, eatable, and pleasant-tasted fruit, which is used in the West Indies for making preserves.

336. PERSEA GRATISSIMA.—The avocado or alligator pear, a common tree in the West Indies. The fruits are pear-shaped, covered with a brownish-green or purple skin. They are highly esteemed where grown, but strangers do not relish them. They contain a large quantity of firm pulp, possessing a buttery or marrow-like taste, and are frequently called vegetable marrow. They are usually eaten with spice, lime-juice, pepper, and salt. An abundance of oil, for burning and for soap-making, may be obtained from the pulp. The seeds yield a deep, indelible black juice, which is used for marking linen.

337. PHŒNIX DACTYLIFERA.—The date palm, very extensively grown for its fruit, which affords the principal food for a large portion of the inhabitants of Africa, Asia, and southern Europe, and likewise of the various domestic animals—dogs, horses, and camels being alike partial to it. The tree attains to a great age, and bears annually for two hundred years. The huts of the poorer classes are constructed of the leaves; the fiber surrounding the bases of their stalks is used for making ropes and coarse cloth; the stalks are used for the manufacture of baskets, brooms, crates, walking sticks, etc., and the wood for building substantial houses; the heart of young leaves is eaten as a vegetable; the sap affords an intoxicating beverage. It may be further mentioned that the date was, probably, the palm which supplied the "branches of palm trees" mentioned by St. John (xii, 13) as having been carried by the people who went to meet Christ on his triumphal entry into Jerusalem, and from which Palm Sunday takes its name.

338. PHORMIUM TENAX.—This plant is called New Zealand flax, on account of the leaves containing a large quantity of strong, useful fiber, which is used by the natives of that country for making strings, ropes, and articles of clothing. The plant could be grown in this climate, and would no doubt be largely cultivated if some efficient mode of separating the fiber could be discovered.

339. PHOTINIA JAPONICA.—The Japanese Medlar, or Chinese Lo-quat. It bears a small oval fruit of an orange color when ripe, having a pleasant subacid flavor. It stands ordinary winters in this climate, and forms a fine evergreen, medium-sized tree.

340. PHYSOSTIGMA VENENOSUM.—A strong leguminous plant, the seeds of which are highly poisonous, and are employed by the natives of Old Calabar as an ordeal. Persons suspected of witchcraft or other crimes are compelled to eat them until they vomit or die, the former being regarded as proof of innocence, and the latter of guilt. Recently the seeds have been found to act powerfully in diseases of the eye.

341. PHYTELEPHAS MACROCARPA.—The vegetable ivory plant, a native of the northern parts of South America. The fruit consists of a collection of six or seven drupes; each contains from six to nine seeds, the vegetable ivory of commerce. The seeds at first contain a clear, insipid liquid; afterwards it becomes milky and sweet, and changes by degrees until it becomes hard as ivory. Animals eat the fruit in its young green state; a sweet oily pulp incloses the seeds, and is collected and sold in the markets under the name of Pipa de Jagua. Vegetable ivory may be distinguished from animal ivory by means of sulphuric acid, which gives a bright red color with the vegetable ivory, but none with the animal ivory.

342. PICRASMA EXCELSA.—This yields the bitter wood known as Jamaica Quassia. The tree is common in Jamaica, where it attains the height of 50 feet. The wood is of a whitish or yellow color, and has an intensely bitter taste. Although it is used as a medicine in cases of weak digestion, it acts as a narcotic poison on some animals, and the tincture is used as fly poison. Cups made of this wood, when filled with water and allowed to remain for some time, will impart tonic properties to the water.

343. PINCKNEYA PUBENS.—This cinchonaceous plant is a native of the Southern States and has a reputation as an antiperiodic. It is stated that incomplete examinations have detected *cinchonine* in the bark. It has been used successfully as a substitute for quinine. A thorough examination of this plant seems desirable so that its exact medical value may be ascertained.

344. PIPER BETEL.—This plant belongs to the *Piperaceæ*. Immense quantities of the leaves of this plant are chewed by the Malays. It tinges the saliva a bright red and acts as a powerful stimulant to the digestive organs and salivary glands; when swallowed it causes giddiness and other unpleasant symptoms in persons unaccustomed to its use.

345. PIPER NIGRUM.—This twining shrub yields the pepper of commerce. It is cultivated in the East and West Indies, Java, etc., the Malabar being held in the highest esteem. The fruit when ripe is of a red color, but it is gathered before being fully ripe and dried in the sun, when it becomes black and shriveled. White pepper is the same fruit with the skin removed. When analyzed, pepper is found to contain a hot acrid resin and a volatile oil, as well as a crystalline substance called *piperin*, which has been recommended as a substitute for quinine.

346. PISTACIA LENTISCUS.—The mastic tree, a native of southern Europe, northern Africa, and western Asia. Mastic is the resin of the tree and is obtained by making transverse incisions in the bark, from which it exudes in drops and hardens into small semitransparent tears. It is consumed in large quantities by the Turks for chewing to strengthen the gums and sweeten the breath. It is also used for varnishing.

347. PISTACIA TEREBINTHUS.—The Cyprus turpentine tree. The turpentine flows from incisions made in the trunk and soon becomes thick and tenacious, and ultimately hardens. Galls gathered from this tree are used for tanning purposes, one of the varieties of morocco leather being tanned with them.

348. PISTACIA VERA.—The pistacia tree, which yields the eatable pistachio nuts. It is a native of western Asia. The nuts are greatly eaten by the Turks and Greeks, as well as in the south of Europe, either simply dried like almonds or made into articles of confectionery.

349. PITHECOLOBIUM SAMAN.—This leguminous plant yields eatable pods, which are fed to cattle in Brazil. Some Mexican species produce pods that are boiled and eaten, and certain portions contain saponaceous properties. The pods are sometimes called Manilla tamarinds. The leaves of this tree fold closely up at night, so that they do not prevent the radiation of heat from the surface of the ground, and dew is therefore deposited underneath its branches. The grass on the surface of the ground underneath this tree being thus wet

with dew, while that under other trees is found to be dry, has given it the name of rain tree, under the supposition that the leaves dropped water during the night.

350. PITTOSPORUM UNDULATUM.—A plant from New Zealand, which reaches a considerable size, and furnishes a wood similar to boxwood. The flowers are very fragrant.

351. PLAGIANTHUS BETULINUS.—The inner bark of the young branches of this plant yields a very fine fiber, sometimes called New Zealand cotton, though more like flax than cotton; it is the Akaroa of the New Zealanders. In Tasmania it bears the name of Currajong. Good cordage and twine for fishing nets are made from this fiber. A superior paper pulp is prepared from the wood; it is also employed in making handles to baskets, rims for sieves, and hoops for barrels.

352. PLATONIA INSIGNIS.—A Brazilian tree which bears a fruit known in that country as Pacoury-uva. The pulp of this fruit is semiacid, very delicious, and is employed in making preserves. The seeds embedded in this pulp have the flavor of almonds.

353. PLUMBAGO SCANDENS.—The root of this plant is called Herbe du Diable in San Domingo; it is acrid in the highest degree, and is a most energetic blistering agent when fresh.

354. PLUMIERIA ALBA.—A South American plant. The flowers are used in perfumery, and furnish the scent known as Frangipane or Frangipani. In Jamaica the plant is known as red jasmine.

355. POGOSTEMON PATCHOULY.—This plant affords the celebrated patchouli perfume. The peculiar odor of patchouli is disagreeable to some, but is very popular with many persons. The odoriferous part of the plant is the leaves and young tops, which yield a volatile oil by distillation, from which an essence is prepared; satchets of patchouli are made of coarsely powdered leaves. Genuine Indian shawls and Indian ink were formerly distinguished by their odor of this perfume, but the test does not now hold good. Ill effects, such as loss of sleep, nervous attacks, etc., have been ascribed to its extensive use.

356. PONGAMIA GLABRA.—Some years ago this tree was recommended as suitable for avenue-planting in the south of France. In India an oil called poonga is expressed from the seeds, which is much used for mixing with lamp oil. It is of a deep yellow color, and is fluid at temperatures above 60 F., but below that it becomes solid.

357. PORTLANDIA GRANDIFLORA—This plant belongs to the cinchonaceous family, and is said to possess properties similar to those of the true cinchona. The bark is exceedingly bitter.

358. PSIDIUM CATTLEYANUM.—This is the purple guava from China. The fruits are filled with juicy, pale flesh, of a very agreeable acid-sweet flavor.

359. PSIDIUM PYRIFERUM.—The West Indian guava, a well-known fruit in the tropics, but only known here in the shape of guava jelly. The wood of the tree has a fine, close grain, and has been experimented with as a substitute for boxwood for engraving purposes, but it is too soft to stand the pressure of printing.

360. PSYCHOTRIA LEUCANTHA.—A plant belonging to the cinchona family. Emetic properties are assigned to the roots, which are also used in dyeing. Native of Peru.

361. PTEROCARPUS MARSUPIUM.—This tree affords gum-kino, which is obtained by making incisions in the bark, from which the juice exudes and hardens into a brittle mass, easily broken into small angular, shining fragments of a bright ruby color. It is highly astringent. The wood is hard and valuable for manufacturing purposes.

362. PUNICA GRANATUM.—The pomegranate, a native of northern Africa and western Asia. The fruit is valued in warm countries on account of its delicious cooling and refreshing pulp. Numerous varieties are grown, some being sweet and vinous, and others acid or of a bitter, stringent taste; the color also varies from light to dark red. The bark of the root abounds in a peculiar principle called *punicin.* This bark appears to have been known to the ancients, and used by them as a vermifuge, and is still used in Hindostan as a specific against tapeworm. The rind of the fruit of the bitter varieties contains a large amount of tannin, and is used for tanning morocco leather. The flowers yield a red dye.

363. QUASSIA AMARA.—The wood of this plant furnishes Surinam quassia. It is destitute of smell, but has an intensely bitter taste, and is used as a tonic. The root has also reputed medicinal value, as also have the flowers.

364. QUILLAJA SAPONARIA.—The Quillai or Cully of the Chilians. Its bark is called soap-bark, and is rough and dark-colored externally, but internally consists of numerous regular whitish or yellowish layers, and contains a large quantity of carbonate of lime and other mineral matters. It is also rich in *saponine*, and is used for washing clothes; 2 ounces of the bark is sufficient to wash a dress. It also removes all spots or stains, and imparts a fine luster to wool; when powdered and rubbed between the hands in water, it makes a foam like soap. It is to be found in commerce.

365. RANDIA ACULEATA.—A small tree native of the West Indies, also found in southern Florida. In the West Indies the fruit is used for producing a blue dye, and medicinal properties are assigned to the bark.

366. RAPHIA TŒDIGERA.—The Jupati palm. The leaf-stalks of this plant are used by the natives of the Amazon for a variety of purposes, such as constructing inside walls, making boxes and baskets, etc. *R. vinifera*, the Bamboo palm, is similarly used by the Africans, who also make a very pliable cloth of the undeveloped leaves. Palm wine is one of the products of the genus.

367. RAVENALA MADAGASCARIENSIS.—This plant is called the Traveler's tree, probably on account of the water which is stored up in the large cup-like sheaths of the leaf-stalks, and which is sought for by travelers to allay their thirst. The broad leaves are used in Madagascar as thatch to cover their houses. The seeds are edible, and the blue, pulpy aril surrounding them yields an essential oil.

368. RHAPIS FLABELLIFORMIS.—The ground rattan palm. This is supposed to yield the walking-canes known as rattan, which is doubted. It is a native of southern China, and is also found in Japan, where it is known by the name of Kwanwortsik.

369. RHIZOPHORA MANGLE.—This plant is known as the mangrove, possibly because no man can live in the swampy groves that are covered with it in tropical countries. The seeds germinate, or form roots before they quit the parent tree, and drop into the mud as young trees. The old plants send out aerial roots into the water, upon which the mollusca adhere, and as the tide recedes they are seen clinging to the shoots, verifying the statements of old travelers that they had seen oysters growing on trees. All parts of this tree contain tannin. The bark yields dyes, and in the West Indies the leaves are used for poulticing wounds. The fruit is edible; a coarse, brittle salt is extracted from the roots, and in the Philippines the bark is used as a febrifuge.

370. ROTTLERA TINCTORIA.—This plant belongs to the order *Euphorbiaceæ*, and reaches the size of a small tree in the Indian Archipelago and southern Australia. From the surface of the trilobed capsules of this plant, which are about the size of peas, a red, mealy powder is obtained, well known in India as kamala, and which is used by Hindoo silk-dyers, who obtain from it a deep, bright, durable orange or flame color of great beauty. This is obtained by boiling the powder in a solution of carbonate of soda. When the capsules are ripe the red powder is brushed off and collected for sale, no other preparation being necessary to preserve it. It is also used medicinally as an anthelmintic and has been successfully used in cases of tapeworm. A solution removes freckles and pistules and eruptions on the skin.

371. RUELLIA INDIGOTICA.—This small bush is extensively cultivated in China for the preparation of a blue coloring-matter of the nature of indigo. The pigment is prepared from the entire plant by a process similar to that employed in procuring the common indigo. It is sold in China in a pasty state. The water in which the plant is steeped is mixed with lime and rapidly agitated, when the coloring deposits at the bottom of the vessel.

372. SABAL ADANSONI.—This dwarf palm is a native of the Southern States. The leaves are made into fans, and the soft interior of the stem is edible.

373. SABAL UMBRACULIFERA.—This is a West Indian palm; the leaves are used for various purposes, such as making mats, huts, etc.

374. SACCHARUM OFFICINARUM.—The sugar cane. Where the sugar cane was first cultivated is unknown, but it is supposed to have been in the East Indies, for the Venetians imported it from thence by the Red Sea prior to the year 1148. It is supposed to have been introduced into the islands of Sicily, Crete,

Rhodes, and Cyprus by the Saracens, as abundance of sugar was made in these islands previous to the discovery of the West Indies in 1492 by the Spaniards, and the East Indies and Brazil by the Portuguese in 1497 and 1560. It was cultivated afterwards in Spain, in Valentia, Granada, and Murcia by the Moors. In the fifteenth century it was introduced into the Canary Islands by the Spaniards and to Madeira by the Portuguese, and thence to the West India Islands and to Brazil. The Dutch began to make sugar in the island of St. Thomas in the year 1610 and in Jamaica in 1644. Its culture has since become general in warm climates and its use universal.

375. SAGUERUS SACCHARIFER.—The arenga palm, which is of great value to the Malays. The black horsehair like fiber surrounding its leaf-stalks is made into cordage; a large amount of toddy or palm wine is obtained by cutting off the flower spikes, which, when inspissated, affords sugar, and when fermented a capital vinegar. Considerable quantities of inferior sago and several other products of minor importance are derived from this palm.

376. SAGUS RUMPHII.—This palm produces the sago of commerce, which is prepared from the soft inner portion of the trunk. It is obtained by cutting the trunk into small pieces, which are split and the soft substance scooped out and pounded in water till the starchy substance separates and settles. This is sago meal; but before being exported it is made into what is termed pearl sago. This is a Chinese process, principally carried on at Singapore. The meal is washed, strained, and spread out to dry; it is then broken up, pounded, and sifted until it is of a regular size. Small quantities being then placed in bags, these are shaken about until it becomes granulated or pearled.

377. SALVADORA PERSICA.—This is supposed to be the plant that produced the mustard seed spoken of in the Scriptures.

378. SANDORICUM INDICUM.—A tropical tree, sometimes called the Indian sandal tree, which produces a fruit like an apple, of agreeable acid flavor. The root of the tree has some medicinal value.

379. SANSEVIERA GUINEENSIS.—Called the African bowstring hemp, from the fibers of the leaves being used for bowstrings.

380. SANTALUM ALBUM.—This tree yields the true sandalwood of India. This fragrant wood is in two colors, procured from the same tree; the yellow-colored wood is from the heart and the white-colored from the exterior, the latter not so fragrant. The Chinese manufacture it into musical instruments, small cabinets, boxes, and similar articles, which are insect proof. From shavings of the wood an essential oil is distilled, which is used in perfumery.

381. SAPINDUS SAPONARIA.—The soapberry tree. The fruit of this plant is about the size of a large gooseberry, the outer covering or shell of which contains a saponaceous principle in sufficient abundance to produce a lather with water and is used as a substitute for soap. The seeds are hard, black, and round, and are used for making rosaries and necklaces, and at one time were covered for buttons. Oil is also extracted from the seeds and is known as soap oil.

382. SAPIUM INDICUM.—A widely distributed Asiatic tree which yields an acrid, milky juice, which, as also the leaves of the plant, furnishes a kind of dye. The fruit in its green state is acid, and is eaten as a condiment in Borneo.

383. SAPOTA ACHRAS.—The fruit of this plant is known in the West Indies as the sapodilla plum. It is highly esteemed by the inhabitants; the bark of the tree is astringent and febrifugal; the seeds are aperient and diuretic.

384. SAPOTA MULLERI.—The bully or balata tree of British Guiana, which furnishes a gum somewhat intermediate between India rubber and gutta-percha, being nearly as elastic as the first without the brittleness and friability of the latter, and requiring a high temperature to melt or soften it.

385. SCHINUS MOLLE.—The root of this plant is used medicinally and the resin that exudes from the tree is employed to astringe the gums. The leaves are so filled with resinous fluid that when they are immersed in water it is expelled with such violence as to have the appearance of spontaneous motion in consequence of the recoil. The fruits are of the size of pepper corns and are warm to the taste. The pulp surrounding the seeds is made into a kind of beverage by the Mexican Indians. The plant is sometimes called Mexican pepper.

386. SCHOTIA SPECIOSA—A small tree of South Africa called Boerboom at the Cape of Good Hope. The seeds or beans are cooked and eaten as food. The bark is used for tanning purposes and as an astringent in medicine.

387. SEAFORTHIA ELEGANS.—This palm is a native of the northern part of Australia, where it is utilized by the natives. The seeds have a granular fibrous rind, and are spotted and marked like a nutmeg.

388. SELAGINELLA LEPIDOPHYLLA.—This species of club moss is found in southern California, and has remarkable hygrometric qualities. Its natural growth is in circular roseate form, and fully expanded when the air is moist, but rolling up like a ball when it becomes dry. It remains green and acts in this peculiar manner for a long time after being gathered. Of late years numbers have been distributed throughout the country under the names of "Rose of Jericho" and "Resurrection Plant." This is, however, quite distinct from the true Rose of Jericho, *Anastatica hierochuntina*, a native of the Mediterranean region, from Syria to Algeria. This plant, when growing and in flower, has branches spread rigidly, but when the seed ripens the leaves wither, and the whole plant becomes dry, each little branch curling inward until the plant appears like a small ball; it soon becomes loosened from the soil, and is carried by the winds over the dry plains, and is often blown into the sea, where it at once expands. It retains this property of expanding when moistened for at least ten years.

389. SEMECARPUS ANACARDIUM.—The marking nut tree of India. The thick, fleshy receptacle bearing the fruit is of a yellow color when ripe, and is roasted and eaten. The unripe fruit is employed in making a kind of ink. The hard shell of the fruit is permeated by a corrosive juice, which is used on external bruises and for destroying warts. The juice, when mixed with quick-lime, is used to mark cotton or linen with an indelible mark. When dry it forms a dark varnish, and among other purposes it is employed, mixed with pitch and tar, in the calking of ships. The seeds, called Malacca beans, or marsh nuts, are eaten, and are said to stimulate the mental powers, and especially the memory; and finally they furnish an oil used in painting.

390. SERISSA FŒTIDA.—A cinchonaceous shrub, having strong astringent properties. The roots are employed in cases of diarrhea, also in ophthalmia and certain forms of ulcers. It is a native of Japan and China.

391. SHOREA ROBUSTA.—This tree produces the Saul wood of India, which has a very high reputation, and is extensively employed for all engineering purposes where great strength and toughness are requisite. It is stronger and much heavier than teak. An oil is obtained from the seeds, and a resin similar to Dammar resin is likewise obtained from the tree.

392. SIDA PULCHELLA.—A plant of the mallow family; the bark contains fibrous tissues available for the manufacture of cordage. The root of *S. acuta* is esteemed by the Hindoos as a medicine, and particularly as a remedy for snake bites. The light wood of these species is used to make rocket sticks.

393. SIMABA CEDRON.—A native of New Grenada, where it attains the size of a small tree, and bears a large fruit containing one seed; this seed, which looks like a blanched almond, is known in commerce as the cedron. As a remedy for snake bites it has been known from time immemorial in New Grenada. It is mentioned in the books of the seventeenth century. Recently it has obtained a reputation as a febrifuge, but its value as an antidote to the bites of snakes and scorpions is universally believed, and the inhabitants carry a seed with them in all their journeyings; if they happen to be bitten by any venomous reptile they scrape about two grains of the seed in brandy or water and apply it to the wound, at the same time taking a like dose internally. This neutralizes the most dangerous poisons.

394. SIMARUBA OFFICINALIS.—This tree yields the drug known as Simaruba bark, which is, strictly speaking, the rind of the root. It is a bitter tonic. It is known in the West Indies as the mountain damson.

395. SIPHONIA ELASTICA.—The South American rubber plant, from which a great portion of the caoutchouc of commerce is obtained. There are several species of siphonia which, equally with the above, furnish the India rubber exported from Para. The caoutchouc exists in the tree in the form of a thin, white milk, which exudes from incisions made in the trunk, and is poured over molds, which were formerly shaped like jars, bottles, or

shoes, hence often called bottle rubber. As it dries, the coatings of milky juice are repeated until the required thickness is obtained, and the clay mold removed. It belongs to the extensive family *Euphorbiaceæ.*

396. SMILAX MEDICA.—This plant yields *Mexican* sarsaparilla, so called to distinguish it from the many other kinds of this drug. The plant is a climber, similar to the smilax of our woods.

397. SPONDIAS MOMBIN.—This yields an eatable fruit called hog plum in the West Indies. The taste is said to be peculiar, and not very agreeable to strangers. It is chiefly used to fatten swine. The fruit is laxative, the leaves astringent, and the seeds possess poisonous qualities. The flower buds are used as a sweetmeat with sugar.

398. STRELITZIA REGINA.—A plant of the Musa or banana family. The flowers are very beautiful for the genus. It is a native of the Cape of Good Hope. The seeds are gathered and eaten by the Kaffirs.

399. STRYCHNOS NUX VOMICA.—This is a native of the Coromandel coast and Cochin-China. It bears an orange-like fruit, containing seeds that have an intensely bitter taste, owing to the presence of two most energetic poisons, *strychnine* and *brucine.* The pulp surrounding the seeds is said to be harmless, and greedily eaten by birds. The wood of the plant is hard and bitter, and possesses similar properties to the seeds, but in a less degree. It is used in India in intermittent fevers and in cases of snake bites. *S. tiente* is a Java shrub, the juice of which is used in poisoning arrows. *S. toxifera* yields a frightful poison called Ourari or Wourari, employed by the natives of Guiana. This is considered to be the most potent sedative in nature. Several species of *Strychnos* are considered infallible remedies for snake bites; hence are known as snakewood. *S. pseudo-quina,* a native of Brazil, yields Colpache bark, which is much used in that country in cases of fever, and is considered equal to quinine in value. It does not contain strychnine, and its fruits are edible. *S. potatorum* furnishes seeds known in India as clearing-nuts, on account of their use in clearing muddy water. St. Ignatius beans are supposed to be yielded by a species of Strychnos, from the quantity of strychnine contained in the seeds.

400. SWIETENIA MAHAGONI.—This South American plant furnishes the timber known in commerce as mahogany. The bark is considered a febrifuge, and the seeds prepared with oil were used by the ancient Aztecs as a cosmetic. The timber is well known, and much used in the manufacture of furniture.

401. TACCA PINNATIFIDA.—This is sometimes called South Sea arrowroot. The tubers contain a great amount of starch, which is obtained by rasping them and macerating four or five days in water, when the fecula separates in the same manner as sago. It is largely used as an article of diet throughout the tropics, and is a favorite ingredient for puddings and cakes.

402. TAMARINDUS INDICA.—The tamarind tree. There are two varieties of this species. The East Indian variety has long pods, with six to twelve seeds. The variety cultivated in the West Indies has shorter pods, containing one to four seeds. Tamarinds owe their grateful acidity to the presence of citric, tartaric, and other vegetable acids. The pulp mixed with salt is used for a liniment by the Creoles of the Mauritius. Every part of the plant has had medicinal virtues ascribed to it. Fish pickled with tamarinds are considered a great delicacy. It is said that the acid moisture exhaled by the leaves injures the cloth of tents that remain under them for any length of time. It is also considered unsafe to sleep under the trees.

403. TANGHINIA VENENIFERA.—This plant is a native of Madagascar, and of the family *Apocynaceæ.* Formerly, when the custom of trial by ordeal was more prevalent than now, the seeds of this plant were in great repute, and unlimited confidence was placed in the poisonous seeds as a detector of guilt. The seeds were pounded, and a small piece swallowed by each person to be tried; those in whom it caused vomiting were allowed to escape, but when it was retained in the stomach, it would quickly prove fatal, and their guilt was thus held to be proven.

404. TASMANNIA AROMATICA.—The bark of this plant possesses aromatic qualities, closely resembling Winter's bark. The small black fruits are used as a substitute for pepper.

405. TECTONA GRANDIS.—The teak tree. Teak wood has been extensively employed for shipbuilding in the construction of merchant vessels and ships of war; its great strength and durability, the facility with which it can be worked, and its freedom from injury by fungi, rendering it peculiarly suitable for these purposes. It is a native of the East India Islands, and belongs to the order *Verbenaceæ*.

406. TERMINALIA CATAPPA.—The astringent fruits of this tropical plant are employed for tanning and dyeing, and are sometimes met with in commerce under the name of myrobalans, and used by calico printers for the production of a permanent black. The seeds are like almonds in shape and whiteness, but, although palatable, have a peculiar flavor.

407. TETRANTHERA LAURIFOLIA.—This plant is widely dispersed over tropical Asia and the islands of the Eastern Archipelago. Its leaves and young branches abound in a viscid juice, and in Cochin-China the natives bruise and macerate them until this becomes glutinous, when it is used for mixing with plaster, to thicken and render it more adhesive and durable. Its fruits yield a solid fat, used for making candles, although it has a most disagreeable odor.

408. THEA VIRIDIS.—This is the China tea plant, whose native country is undetermined. All kinds and grades of the teas of commerce are made from this species, although probably it has some varieties. Black and green teas are the result of different modes of preparation; very much of the green, however, is artificially colored to suit the foreign trade. The finest teas do not reach this country; they will not bear a sea voyage, and are used only by the wealthy classes in China and Russia. The active principles of the leaves are theine and a volatile oil, to which latter the flavor and odor are due. So far as climate is concerned for the existence of the tea plant in the United States, it will stand in the open air without injury from Virginia southwards. A zero frost will not kill it. But with regard to its production as a profitable crop, the rainfall in no portion of the States is sufficient to warrant any attempt to cultivate the plant for commercial purposes. But this does not prevent its culture as a domestic article, and many hundreds of families thus prepare all the tea they require, from plants it may be from the pleasure ground or lawn, where the plant forms one of the best ornaments.

409. THEOBROMA CACAO.—This plant produces the well-known cacao, or chocolate, and is very extensively cultivated in South America and the West India Islands. The fruit, which is about 8 to 10 inches in length by 3 to 5 in breadth, contains between fifty and a hundred seeds, and from these the cacao is prepared. As an article of food it contains a large amount of nutritive matter, about 50 per cent being fat. It contains a peculiar principle, which is called *theobromine*.

410. THEOPHRASTA JUSSLÆI.—A native of St. Domingo, where it is sometimes called Le petit Coca. The fruit is succulent, and bread is made from the seeds.

411. THESPESIA POPULNEA.—A tropical tree, belonging to the mallow family. The inner bark of the young branches yields a tough fiber, fit for cordage, and used in Demerara for making coffee bags, and the finer pieces of it for cigar envelopes. The wood is considered almost indestructible under water, and its hardness and durability render it valuable for various purposes. The flower buds and unripe fruits yield a viscid yellow juice, useful as a dye, and a thick, deep, red-colored oil is expressed from the seeds.

412. THEVETIA NERIIFOLIA.—This shrubby plant is common in the West Indies and in many parts of Central America. Its bark abounds in a poisonous milky juice, and is said to possess powerful properties. A clear, bright, yellow-colored oil, called Exile oil, is obtained, by expression, from the seeds.

413. THRINAX ARGENTEA.—This beautiful palm is called the Silver Thatch palm of Jamaica, and is said to yield the leaves so extensively used in the manufacture of hats, baskets, and other articles. It is also a native of Panama, where it is called the broom palm, its leaves being there made into brooms.

414. TILLANDSIA ZEBRINA.—A South American plant of the pineapple family; the bottle-like cavity at the base of the leaves will sometimes contain a pint or more of water, and has frequently furnished a grateful drink to thirsty travelers.

415. TINOSPORA CORDIFOLIA.—A climbing plant, so tenacious of life that when the stem is cut across or broken, a rootlet is speedily sent down from above, which continues to grow until it reaches the ground. A bitter principle, *calumbine*, pervades the plant. An extract called galuncha is prepared from it, considered to be a specific for the bites of posionous insects and for ulcers. The young shoots are used as emetics.

416. TRIPHASIA TRIFOLIATA.—A Chinese shrub, with fruit about the size of hazelnuts, red-skinned, and of an agreeable sweet taste; when green, they have a strong flavor of turpentine, and the pulp is very sticky. They are also preserved whole in sirup, and are sometimes called limeberries.

417. TRISTANIA NERIFOLIA.—A myrtaceous plant from Australia, called the turpentine tree, owing to its furnishing a fluid resembling that product.

418. URCEOLA ELASTICA.—A plant belonging to the *Apocynaceæ*, a native of the islands of Borneo and Sumatra, where its milky juice, collected by making incisions in its soft, thick, rugged bark, or by cutting the trunk into junks, forms one of the kinds of caoutchouc called juitawan, but it is inferior to the South American, chiefly owing to want of care in its preparation, the milky juice being simply coagulated by mixing with salt water, instead of being gradually inspissated in layers on a mold. The fruit contains a pulp which is much eaten by the natives.

419. URENA LOBATA.—A malvaceous plant, possessing mucilaginous properties, for which it is used medicinally. The bark affords an abundance of fiber, resembling jute rather than flax or hemp.

420. UVARIA ODORATISSIMA.—An Indian plant which is supposed to yield the essential oil called Ylang-Ylang, or Alan-gilan. This oil is obtained by distillation from the flowers, and is highly esteemed by perfumers, having an exquisite odor partaking of the jasmine and lilac.

421. VANGUERIA EDULIS.—A cinchonaceous plant, the fruits of which are eaten in Madagascar under the name of Voa-vanga. The leaves are used in medicine.

422. VANILLA PLANIFOLIA.—The vanilla plant, which belongs to the orchid family. The fruit is used by confectioners and others for flavoring creams, liquors, and chocolates. There are several species, but this gives the finest fruit. It is a climbing orchid, and is allowed to climb on trees when cultivated for its fruit. In Mexico, from whence is procured a large portion of the fruit, it is cultivated in certain favorable localities near the Gulf coast, where the climate is warm. Much of the value of the bean depends upon the process of its preparation for the market. In Mexico, where much care is given to this process, the pods are gathered before they are fully ripe and placed in a heap, under protection from the weather, until they begin to shrivel, when they are submitted to a sweating process by wrapping them in blankets inclosed in tight boxes; afterwards they are exposed to the sun. They are then tied into bundles or small bales, which are first wrapped in woolen blankets, then in a coating of banana leaves first sprinkled with water, then placed in an oven heated up to about 140° F. Here they remain for twenty-four to forty-eight hours, according to the size of the pods, the largest requiring the longest time. After this heating they are exposed to the sun daily for fifty or sixty days, until they are thoroughly dried and ready for the market.

423. VATERIA INDICA.—This plant yields a useful gum resin, called Indian copal, piney varnish, white dammar, or gumanine. The resin is procured by cutting a notch in the tree, so that the juice may flow out and become hardened. It is used as a varnish for pictures, carriages, etc. On the Malabar coast it is manufactured into candles, which burn with a clear light and an agreeable fragrance. The Portuguese employ this resin instead of incense. Ornaments are fashioned from it under the name of amber. It is also employed in medicine.

424. WEINMANNIA RACEMOSA.—A New Zealand tree called Towhia by the natives of that country. Its bark is used for tanning purposes, and as a red and brown dye, which give fast colors upon cotton fabrics.

425. WRIGHTIA TINCTORIA.—The leaves of this plant furnish an inferior kind of indigo. The wood is beautifully white, close-grained, and ivory-like, and is much used for making Indian toys.

426. XANTHORRHŒA ARBOREA.—The grass gum tree of Australia, also called black boy. This is a liliaceous plant, which produces a long flower-stalk, bearing at the top an immense cylindrical flower-spike, and when the short

black stem is denuded of leaves, the plants look very like black men holding spears. The leaves afford good fodder for cattle, and the tender white center is used as a vegetable. A fragrant resin, called acaroid resin, is obtained from it.

427. XIMENIA AMERICANA.—A small tree, found in many warm regions; among others in southern Florida. In Brazil it is called the Native Plum on account of its small yellow fruits, which have a subacid and somewhat astringent aromatic taste. The wood is odoriferous and is used in the West Indies as a substitute for sandalwood.

428. YUCCA ALŒFOLIA.—The yucca leaves afford a good fiber, and some southern species are known as *bear's grass.* The root stems also furnish a starchy matter, which has been rendered useful in the manufacture of starch.

429. ZAMIA FURFURACEA.—This plant belongs to the order *Cycadeaceæ*, and is grown to some extent for the starchy matter contained in the stem, which is collected and used as arrowroot; but it is not the true arrowroot, that being produced by a species of *Maranta.*

430. ZAMIA INTEGRIFOLIA.—The coontie plant of Florida. The large succulent roots afford a quantity of arrowroot, said to be equal to the best of that from Bermuda. The fruit has a coating of an orange-colored pulp, which is said to form a rich edible food. It was from the roots of this plant that the Seminoles of Florida obtained their *white meal.*

421. ZINGIBER OFFICINALE.—This plant is cultivated in most warm countries for the sake of its rhizomes, which furnish the spice called ginger. It is prepared by digging up the roots when a year old, scraping them, and drying them in the sun. Ginger, when broken across, shows a number of little fibers embedded in floury tissue. Its hot pungent taste is due to a volatile oil. It also contains starch and yellow coloring matter. Ginger is used for various medicinal purposes, and in many ways as a condiment, and in the preparation of cordials and so-called teas.

INDEX.

A.

D.

I.

P.

W.

X.

Z.

ERRATA.

Page 134, line 9, for might prove beneficial, read might not prove very objectionable.
Page 379, line 20, for *Brumus unioloides*, read *Bromus unioloides*.
Page 379, line 39, for *Paspalum dilitatum*, read *Paspalum dilatatum*.
Page 389, line 6, for *Linaria canadensis*, read *Linaria vulgaris*.

O